PSYCHOLOGY YOU CAN USE

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To Thomas and Dora

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PSYCHOLOGY YOU CAN USE

people to buy their goods. Employers are eager to learn how they can get the best possible work from their employees. Workers learn how they must act if they want their employers to pay them their wages. In all our relationships with human beings we find that we need to understand and to control human behavior.

Many of us have to manage animals. Hunters, trappers, and fishermen study the ways of animals in order to kill or capture them. Housekeepers study at least some of the ways of rats and cockroaches and other pests in order to rid their houses of them. Some animals, such as horses, dogs, and elephants, can be trained to do useful work. And a trained animal act is a part of every circus.

Man is an extremely curious animal and his curiosity has led to the development of many sciences. Most of them have names that end in *ology,* like mineralogy, the study of minerals, and zoology, the study of living animals.

Psychology, the science of behavior and experience, undertakes to explain why people and animals act as they do. It is the study of ourselves and other living beings as creatures who are seeing, hearing, thinking, acting, desiring, happy, sad, angry, and so on.

Anatomy is the study of the way in which bodies are made—their structure. It deals with bones, muscles, nerves, glands, and all the numerous bodily organs. Physiology is

the study of the ways in which all those structures work in health and disease. But anatomy and physiology cannot give a complete account of human or even animal activities.

We do much more than merely live. We have many experiences. They are of many kinds. We act. Our actions may have extremely important consequences. We cannot leave such important matters to chance or accident. We certainly need a science that will enable us to understand, and so to control, experience and behavior.

Psychology is that science. If we want to use the word in its widest possible meaning, we can say that any attempt to understand or control the behavior or experience of human beings or animals can be called psychology. Some scientists have even studied and written about the behavior of plants! Most of us are busy nearly all our waking hours trying to manage others or to adjust ourselves to others' ways, or simply to understand ourselves or others. So we could say that we are all of us psychologists.

The science of psychology is a body of knowledge about behavior and experience that has been tested until we have a right to feel sure of it, that is exact rather than vague, that is true for everyone and everywhere, and that fits together in a system we can at least partly understand.

In general the answer to the question, How do people get that way? is very simple, and everybody knows it. They get that way by piling up habits. Everyone knows that the more frequently we perform an act, the easier we find it, the readier we are to do it, and the less thought or effort it requires.

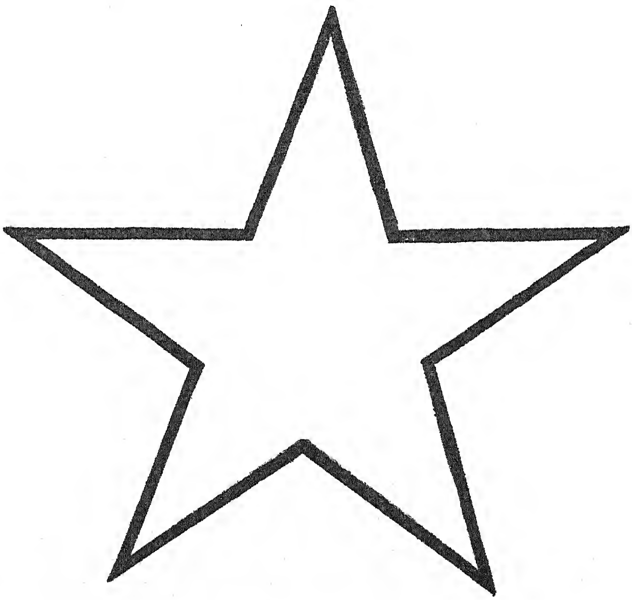
Back in the days when fire engines were drawn by horses, one of these horses became too old for such strenuous duty and was sold to a milkman. One day he happened to be passing his old engine house just as the alarm rang and the engines came dashing out. He followed them at a gallop and nothing his new driver could do would stop him until he came to the fire.

There is another story of a man whose wife sent him upstairs to dress for a dinner to which guests had been invited. When he sat down on the bed and began to pull off his shoes, a chain of old, firmly established habits began to work so strongly that he undressed completely, put on his pajamas, and got into bed. When his wife came up to see why he was so long about dressing, she found him sound asleep.

With very little apparatus, and that of the very simplest sort, we can set out to develop a new habit and watch it grow. The experiment is amusing and will supply an excellent illustration of some of the ways in which

psychologists study human behavior. The habit, of course, will have to be a very simple and easily acquired one.

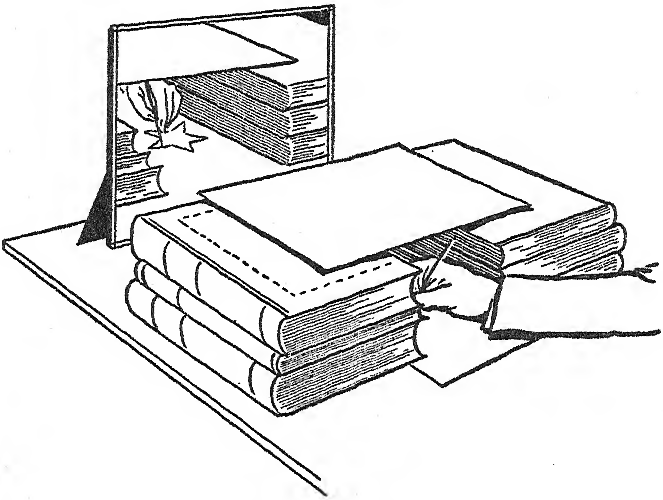
Trace or draw fifteen or twenty copies of the star



shown in the illustration. Make each copy on a separate piece of paper.

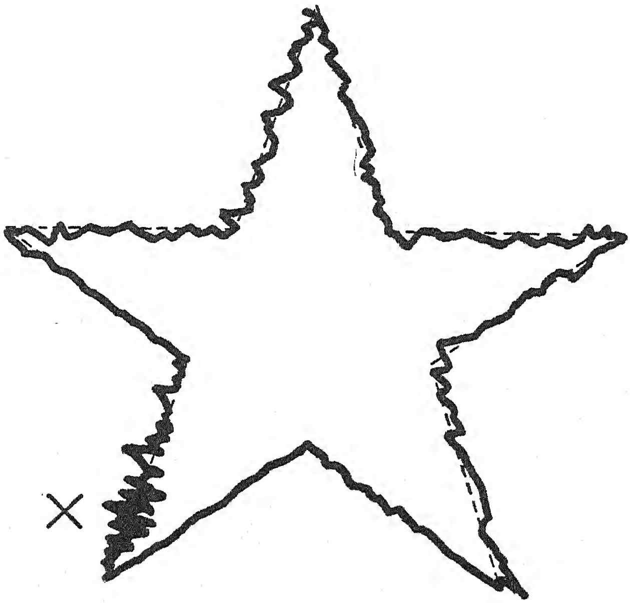
Then take a mirror and prop it up against some books or other support on a table. A mirror about as large as this page will probably be the most convenient, though the size is not important. Place a sheet of paper with the star on it in front of the mirror. Arrange a screen so that

you cannot see the star directly but can do so easily in the mirror. You can hold a piece of cardboard in your hand to make the screen, or you can lay it across two piles of books. An illustration shows you one way to do it.



Now take a pencil and try to trace the outline of the star. Watch your pencil and your hand in the mirror. Begin at any point you please and work in any direction you please. If your pencil gets off the line, bring it back to the line at once. Get a friend to time you as you work. If you have a stop watch or can borrow one, it will make the timing very easy; but any watch with a second hand will do well enough. Trace the star ten, twenty, or even

more times. You can use each sheet of paper two or three times. After each trial write down the number of seconds you needed to go completely around the star and return to your starting point.



At first you will find it very difficult. Some people need as much as five minutes to go all the way around. Probably you will find, too, that at some points your pencil will seem to stick fast. Every move you try to make will be wrong. At such times some persons' muscles grow so tense that the struggle is almost painful. At the same time

it is funny. It is so ridiculous to be stuck—indeed almost paralyzed—in such an absurd position. One person's tracing on the fifth trial is illustrated. See what a struggle there must have been at the point marked X.

As you try again and again, you will find that you will be able to do the task in a shorter and shorter time. Before you have used up all your copies of the star, you will probably be getting all the way around in as short a time as fifteen seconds, perhaps even in ten seconds. You will find it easier, too, to stay on the line.

We have been repeating an experiment that has been performed in psychological laboratories probably thousands of times. You have developed a new habit. Perhaps we ought to say a new set of habits. Little by little you learned to adjust the movements of your hand to what you saw in the mirror. You have kept a record. You have watched the habit grow from very rough and crude beginnings to a fair degree of skill.

The first thing our experiment shows is that learning any new habit or skill requires practice. The more we practice any act, the better we shall be able to do it.

There are limits, of course, beyond which we cannot go, no matter how long or how hard we practice. And just as there are limits beyond which you and I cannot go, there are other limits beyond which no one at all can

go. No human being, so far as we have any record, has ever run a hundred yards in nine seconds or a mile in four minutes. The strongest man of whom we have any reliable reports once lifted a weight of four thousand pounds! Even he could not have lifted five thousand.

One of the surprising things psychologists have learned is that almost no one ever reaches the real limit of what he could do. Even skilled typesetters and bricklayers, men who have worked at their trades for many years and have become expert at them, have found that with a little practice under careful direction they have been able to do very much better than they have ever done before. Practice, it is plain, does not always make perfect.

To do something better after practice may mean any or all of three things. It may mean that we do it more rapidly or in a shorter time. It may mean that we make fewer mistakes. Mistakes are wrong or useless movements. The wrong movements interfere with the right ones and block them. The useless movements, even if they do not block the right ones, at least waste time and energy. One of the reasons why practice does not make perfect is that we frequently practice, and keep on practicing, wrong movements. Finally, it may mean that we do it more easily; that is, it requires less effort and tires us less.

The most difficult part of drawing the star while look-

ing in the mirror was learning not to do certain things. When you were able to stop doing them, the way was clear for the right moves. That made the right moves both easy and rapid.

The same thing is true of many other kinds of learning. Watch anyone who is just learning to skate, to swim, to dance, or to do almost anything. See how many movements he makes that are not needed and that may even interfere with what he is trying to do. Watch him again, when he has become skillful. See how few such unnecessary movements he makes. Note the perfect working together and timing of every act.

There is much more to learning, though, than practice. Before you had made many trials, you surely noticed that it was easy enough to trace the lines that ran from right to left or from left to right. Your troubles began, you found, when you had to move your pencil toward you or away from you. In the mirror every such move looked exactly the opposite of what you felt it was and knew it must be. When you pulled the pencil toward you, it looked as though you were pushing it away; and when you pushed it away, it seemed to be coming toward you. That was what made it so confusing.

As soon as you noticed that, you probably said to yourself, "It looks as though I ought to push the pencil away

from me, but that means I must pull it toward me." As soon as you understood just what your difficulty was, and what you would have to do about it, the right movements quickly became easier and there was much less temptation to do the wrong things.

This understanding of a task or a problem psychologists call insight. We can make some improvements in many of our habits without it, or at least without very much of it, but insight certainly helps greatly. Some things we can never learn at all unless we can see the reasons for them, or how one part of a problem is connected with another.

Long before this little experiment you knew that you must practice anything if you want to do it well. Perhaps you are wondering whether you have really learned anything new after all.

For thousands of years men knew that heavy bodies, if we drop them from heights, would fall to the ground. Men knew, too, that the farther anything fell, the faster it would be moving when it struck. About three hundred and fifty years ago a great scientist, Galileo, began to wonder just how fast bodies fell, whether heavy bodies fell faster than light ones, and why they fell at all. The story of his experiments and discoveries is one of the most fascinating of all the true stories of science. Because he

was not satisfied with knowing that bodies fell, but was determined to find out just how fast they fell, men ever since his day have had a better understanding of motion. The whole of the great science of mechanics rests upon his discoveries.

It is not enough to know only that skill improves with practice. We need to know just how it does so. Psychologists have studied many kinds of learning. We have found ways to make records of performance and to measure progress, we can compare one way of learning with another. So we can find out which is the better. In the same way we can find out which methods of teaching are the most effective. We can compare one individual with another and find out how they differ in their abilities. That will make it possible for us to know better than we ever could before just what we have a right to expect from human beings of different ages and under different conditions. That is all extremely important and valuable knowledge. We can put it to use in schools, in factories, in the army and navy, in our homes, in just about every place or situation where anybody needs to learn to do anything better.

Is there something you would like to learn to do better than you can do it now? Think up some way to measure how well you do it. Set aside definite practice periods.

Keep a record day by day. Draw a chart so that you can see what progress you are making. Keep alert to discover and to eliminate anything that may be holding you back. Get some of your friends to try the same experiment. You will find it interesting and you will be surprised at the progress you will make.

Measuring is a very large part of the work of any scientist. Psychologists have worked out many ingenious ways to measure at least some of the characteristics of behavior and experience. One of the easiest things to measure is the time required to respond to a stimulus or to complete a task. Many factories employ men to study carefully the time each worker needs for every part of his job. Often such studies lead to the discovery of quicker and easier ways to do the things that must be done. That means, of course, a larger output, often a better quality of work, lower costs, and so larger profits.

Psychologists also measure such things as the faintest tone one can hear, the lowest tone, and the highest, the smallest differences you can detect between sounds, lights, pressures, smells, and tastes that are almost (but not quite) the same. They can even measure with some success how intelligent a boy or girl, or a man or woman, may be.

You will read about many experiments in the chapters

to come. In some respects they are all very much alike. Always there is an experimenter. The person on whom the experiment is made is called the subject, or sometimes the observer. The experimenter does something to the subject. A better word for scientific purposes than "does something" is stimulates. The usual way of putting it is to say that the experimenter presents a stimulus.

The stimulus may be a picture, a sound, a light, a touch. Anything at all is a stimulus that causes the subject to do something—to move, to speak, to change his rate of breathing, or simply to take notice. What the subject does as a result of the stimulus is called his response or reaction. The experimenter measures both the stimulus and the response and keeps as careful records as he can of everything that seems likely to be of interest.

No one can yet tell us in any great detail nor with any certainty just how we learn to do even the simplest acts or just why doing an act over and over again enables us to do it any better. Psychologists feel very certain that it is due to changes of some kind in our nerves; but no one knows just what those changes are. Our nerves carry impulses from our eyes and ears and other organs to the brain. Other nerves carry impulses out from the brain to our muscles. The brain is like an enormous switchboard connecting the incoming impulses with the outgoing. Mil-

lions of impulses come in every minute and millions more go out. The connections necessary even for what seem very simple activities are extremely numerous and complicated. If action is to be quick and efficient, it is plain that just the right connections, and no others, must be made.

It seems almost certain that the passage of a nervous current through certain connections makes it easier to pass that way the next time. After the impulse has passed through the right connections many times, we may suppose that it does so much more easily than through other connections that have not been used so often. We must suppose further that somehow the wrong connections are made more and more resistant, the right ones more and more easily penetrable.

Something like that is almost certainly true. But no one knows definitely just what happens, and we do not seem very close to finding out.

This, however, should not be surprising. Psychology is one of the very youngest of the sciences. Its problems are far more complicated than those of the other sciences. Even the simplest living creature is far more complicated than the most intricate machine men have ever devised. Of every science, moreover, it is true that "the larger the radius with which we draw the circle of our knowl-

you would find warm spots in the same way you found the cold. Of course they would not be the same spots.

Now, anywhere at all on your skin, press a little harder and a little harder, until it begins to hurt.

At first there is only pressure and more pressure. Then, all at once, you feel a sting. Is that sting just more pressure, harder or more severe pressure? Or is it something new and different?

Most of the scientists who have studied this matter carefully believe it is entirely different. One of them remarked that such pain is as different from pressure as blue is. Later we shall find another reason to believe that it is different from pressure or warm or cold.

This little exploration brings to light the surprising fact that distinct and separate spots on the skin yield at least four different sensations—pressure, warmth, cold, and pain. Psychologists are not all agreed as to why this is so. Probably the majority believe that the skin is crowded with little structures that we may compare to four kinds of tiny radios, one set to receive and report cold, another set for warm, another tuned to pressure, and still another ready to report pain. Or we may think of the skin as filled with tiny little reporters, each one ordered to watch for and to report just one kind of happening.

Now we can understand why the hot water felt cold before it felt hot. Sometimes it is difficult to prevent a station you do not want to listen to from interfering with a program on your radio that you do want. The little radios in the skin that are tuned in for cold are set in action also by heat, but the only messages they are built to send are "cold," "cold." The cold spots, moreover, are a little quicker than the warm spots in getting into action, or responding. By very careful experiments scientists have found that the cold spots respond in about fifteen one-hundredths ($^{15}/_{100}$) of a second, the warm in about eighteen ($^{18}/_{100}$). For a few hundredths of a second, then, the only radios in action are those that report "cold."

Though the hot water felt cold for a moment, it was only for a few hundredths of a second. Soon it felt hot. Perhaps it was hot enough to hurt. If it hurt, something else must have been in action besides the warm and the cold spots. One of the surprising discoveries made by psychologists and physiologists who have studied the sensations we get from the skin is that hot is more than just a strong, vigorous, or intense warm. It is really a mixture, or blend, of warm, cold, and pain.

By using what is called a temperature grill some experimenters have been able to make people report "hot"

when there was nothing more than moderate warmth touching the skin. The grill is made of many small copper tubes very close together. Some of them are kept warm and the others cold by warm or cold water circulating through them. When one of these grills is pressed against a person's skin, let us say on his forearm, he will report "hot," though there is nothing really hot at all. The cold points arouse the cold spots, the warm points the warm. In 1930 two American scientists applied cold, warm, and weak electric shocks. This three-fold stimulation was described as burning hot.

Now we can understand why extremely cold things such as the dry ice can feel hot. Severe cold arouses pain sensations in addition to the cold. Just recall how your face or your fingers or your toes sting and burn when the temperature is below zero! Possibly there are also sensations of warmth—though we cannot be sure about that. So extreme cold feels very much like hot.

From millions of points in the skin tiny fibers that we call nerves run into the spinal cord and up into the brain. There are reasons to believe that those which report warm, cold, pain, and pressure lie each in a different part of the spinal cord. There is a disease of the spinal cord—a very rare one—which destroys the nerves that carry the sensations of warm, cold, and pain but leaves those that report

pressure intact.

If a sufferer from this disease should be blindfolded, he could put his hand on a red hot stove and never know that the stove was hot. He would know that he was touching something hard, but he could allow his hand to stay there and fry without feeling the least pain or discomfort!

We begin to feel pain at temperatures close to ten degrees centigrade or fifty degrees Fahrenheit. Of course it does not really hurt then. There is just enough sting or bite to be recognized as such. As the object we may be touching becomes colder and colder, the pain increases. At zero degrees (thirty-two degrees Fahrenheit), the temperature at which water normally freezes, the pain becomes severe. You would not want to hold a piece of ordinary ice very long or very tightly in your hand.

We begin to feel pain again at about fifty degrees centigrade. This is about one hundred and twenty-two degrees Fahrenheit. A cup of coffee at that temperature is about as hot as most people can drink. A bath heated to 122° is quite a little hotter than most people like. From this point on, pain rapidly becomes more and more intense. The pain of large and severe burns is probably the most excruciating we can suffer.

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grade—ninety-two degrees Fahrenheit. That is just a little cooler than the normal temperature of the blood—ninety-eight degrees Fahrenheit or thirty-seven degrees centigrade. The sensation of cold increases in intensity as the temperature goes lower and lower. It may be that there is a limit beyond which nothing could feel any colder. It would be difficult to make the necessary experiments to determine this, however, since anything as cold as that would probably be unendurably painful.

We feel cold again at temperatures of about forty-five degrees centigrade, one hundred and thirteen degrees Fahrenheit. As the temperature rises, the sensation of cold is felt more and more strongly. That is why, as we have seen, hot water can for a few hundredths of a second feel cold.

We begin to feel warm at just about the same point as cold, thirty-three degrees centigrade or ninety-two degrees Fahrenheit. At any temperature above fifty degrees centigrade (one hundred and twenty-two degrees Fahrenheit), we feel cold and warm and pain. At about freezing, and of course for all temperatures below that, we feel cold and pain. We say that it is biting cold.

Some places on our bodies are very much more sensitive than others. That is because they have many pain spots and because those spots are close to the surface of

the skin. The scalp is one of the least sensitive portions of the body. A cut there may look very terrible, because it bleeds freely, but usually it hurts very little. Our lips, on the other hand, are very sensitive. So are the tissues under our finger and toe nails, as anyone knows who has run a sliver deep underneath a nail! Perhaps the most sensitive part of all is the cornea of the eye. Even a tiny grain of sand or a cinder hurts if it gets into your eye.

This explanation of the "spots" on the skin and of our experiences of cold, hot, pressure, and pain is probably the one that is most generally accepted today. But we have already remarked that psychologists are not all agreed that it is correct. The most serious difficulty with it is that the most careful microscopic study of the skin fails to show underneath the various "spots" the four different kinds of structures, the "radios," for which the theory calls. The same "spot," it seems, can be made to yield all four sensations, if the stimuli are strong enough.

A more recent theory denies that there are any such specialized structures as those we have been imagining. According to this new theory a stimulus anywhere on the surface of the skin will be felt as pressure. A mildly cold stimulus will cause the surrounding blood vessels to contract. A warm stimulus will make them relax. A stronger stimulus, either warm or cold, will cause them

to contract and relax alternately. A sufficiently strong stimulus of any kind, pressure, warm, or cold, will arouse pain, because the nerves will react in a very jumpy, irregular fashion.

We will not try to decide between the two theories. The fact that there are two such very different theories of one of the very simplest matters in our study of human experience is evidence that psychology is still a very young science and that psychologists have made only a beginning at their work.

Scientists are always finding that even the simplest things around us are much more complicated than they supposed. Theories that may be entirely satisfactory for a long time sooner or later fail to explain newly discovered facts. Then new theories must be worked out. But scientists do not accept the new theories all at once. They welcome them and study them with lively interest, but they wait, perhaps for many years, until the evidence for one theory or another seems decisive.

When you have gone swimming, you must have noticed that although the water felt cold at first, it soon ceased to do so. You may have noticed that a bath that at first was almost too hot to be endured, before long came to feel very comfortable. This change in our sensations is called adaptation. We get used to rather a wide

range of temperature. The warm and the cold spots, even to some extent the pain spots, no longer send in their reports. It takes a change in one direction or another to stir them up, or to stimulate them.

There is a very old experiment that you can easily repeat. Fill three pans with water, one with water as cold as you can get it, one with as hot as you can stand, and one with lukewarm water. Place one hand in the hot water and one in the cold. Allow them to stay there until they are thoroughly adapted. Then put both hands into the lukewarm water. The lukewarm water will feel warm to the hand that has become adapted to the cold water and cold to the one that has been in the hot.

There are limits beyond which we cannot adapt. The more the temperature differs from the ordinary temperature of the skin, the longer it takes to adapt to it. If it is too hot or too cold or too painful, we cannot adapt at all.

Frogs seem able to adapt themselves to very high temperatures. If the water in which a frog is sitting is heated very slowly, the frog may let himself be boiled to death without making any effort to jump out and without showing any signs of discomfort. If we were as adaptable as frogs, we would not need coats in winter and would not feel hot in summer.

CHAPTER III

THE SENSE OF MOVEMENT AND SOME OTHER SENSES

Do you know where your hands and feet are or what they are doing? How do you know? Do you need to look to be quite sure? If you were blindfolded, would you have any difficulty in pointing to your right foot or your left ear?

These questions are not as silly as they probably seem. Some persons really do not know where their hands or feet are, unless they can see them. If a man with a severe case of locomotor ataxia lying blindfolded in bed is asked to point to his right foot, which an attendant moves to one position after another, he will make blunders that seem incredible. The attendant may lift and bend the patient's leg until his foot is close to his head, yet the patient may believe it is in some natural position!

We who do not suffer from locomotor ataxia know what we are doing, because there are hundreds of thousands, perhaps millions, of tiny little reporters, or recep-

tors, in our muscles, our tendons, and the surfaces of our joints, and because these instantly notify us of tensions, relaxations, and movements. These sensations we call kinesthetic—from two Greek words meaning movement and sensation. Kinesthetic, of course, is an adjective. The noun is kinesthesis. It means an experience of movement.

To realize how important kinesthetic sensations are, walk a few steps. Note carefully the tensing and relaxing of different muscles in the feet, legs, trunk, arms, and neck. Suppose any of these muscles did their parts a little too soon, a little too late, a little too vigorously, or not quite energetically enough! If one is to walk efficiently or gracefully, it is plain that each tension and relaxation must take place at exactly the right time and to exactly the right amount. Walking is really a very complicated activity in which scores of muscles have to pull or let go in perfect teamwork.

If you will think over the number of muscles involved and the exact timing and judgment of distance that are necessary, you will realize that every step is far more complicated than any football play that was ever executed. Success is possible because every movement, tension, or relaxation is a cue or signal for the next. And that is possible because the receptors in our muscles, tendons, and joints are continually sending in their innumer-

able reports to the brain.

Locomotor ataxia is a disease that attacks a particular region of the spinal cord. That is the region through which run the nerves carrying the sensations of movement, of strain, and of letting go. That is why the patient cannot know what his arms and legs are doing, or even in what position they are, unless he can see them. And since no messages of the necessary sort, or at least not enough of them, come into his brain, no movement can be a clear signal for the next. So it is not surprising that every complicated movement is awkward and erratic. The wonder is rather that they can be effective at all. Imagine a general trying to direct a battle after he has lost all touch with the units of his army, or the manager of a business giving orders but with no information as to what is happening in the various departments!

An odd, even an amusing, little disturbance of kinesthetic sensations is easily produced. Stand with your shoulder against a wall and your arm hanging straight at your side. Try to raise your arm sideways. Keep on trying until the muscles of your arm and shoulder are well tired. Then step away suddenly. Note how your arm seems to rise almost by itself and how light it feels!

Another interesting little experiment is to compare the estimate of distance by the kinesthetic sense with that

by vision. Place two dots on a sheet of paper three or four inches or more apart. Place the point of a pencil on one of the dots. Close your eyes. Now draw a line to the other dot. Draw several such lines, measure the errors, and find the average of them. With practice, of course, you will become more accurate. You can vary this by making two dots on a sheet of paper with your eyes closed, guessing the distance, and then measuring it. Do the same things with your eyes open, guessing the distance by the look of it. Is vision or the muscle sense closer to the right measure? Do you notice a consistent tendency in either sense to underrate or overrate the distance?

It is easy enough to see that kinesthetic sensations play a very important part in every kind of muscular skill. Not many people realize how large a part they are of other and more complex experiences. We very soon learn to put together our kinesthetic experiences and the changes in the looks of things as we move toward them or away from them, reach for them, or handle them. So, as we shall see in a later chapter, we learn to perceive or judge distance. Kinesthetic sensations are always with us, most of the time as a vague background to any experience or activity in which we may be actively interested. The emotion of grief or sorrow consists in part, at least, of the kinesthetic sensations of relaxed muscles, of weak-

ness, drooping shoulders, difficult breathing, sagging features, and heart ache due to constriction of the heart muscles. The feeling of well-being, on the other hand, is largely a matter of muscles tense and ready for quick, vigorous action. Excitement is very largely, perhaps almost wholly, a feeling of muscular tension. The sensations of actual movement, of the readiness to move, of tension and relaxation flow over our bodies in ever-changing patterns. The next time you watch an exciting athletic contest or moving picture, take a few moments off now and then to observe your own behavior and experience. You may be surprised to find how your muscles are following the happenings on the field or the screen.

Another sense that is very important for bodily movement is the sense of equilibrium. The structures involved in this are the semi-circular canals in the middle ear. These act somewhat like an automatic stabilizer in an aeroplane. Whenever the position of the head changes, forward or backward, sideways to the right or left, or by rotation in either direction, a fluid in one or another of the three canals is set in motion. Tiny hairs pick up the motion and pass it on to nerves that connect with the brain. From the brain impulses go out to the muscles and to the eyes. Again our muscles co-operate in their wonderful teamwork, and the movements that the situation demands are

made quickly, and for the most part without thought or conscious effort.

Persuade some friend to stand with heels close together and eyes closed. Notice how he or she sways forward and back, and from side to side. Try it yourself. Can you detect the sway in your own case? How do you manage to keep from falling over? To some extent you get the necessary cues from kinesthetic sensations in your feet, but the little canals in your ears are also doing their part.

Individuals vary in this trait as in every other. Those with some defect in the canals or in the nerves connected with them are unable to stand upright. Unless they are supported by someone else, or open their eyes, they are likely to fall. A very keen sensitiveness to changes of bodily position or balance is obviously very necessary for aviators. Divers, acrobats, and dancers also depend largely upon this sense of equilibrium.

If you are willing to suffer a rather severe case of dizziness, and perhaps a little nausea, you can easily bring out some of the effects of stimulating the canals. Hold a yard stick, a cane, or an umbrella upright with one end on the floor. Bend down until your forehead touches the upper end. In this stooping position walk around it ten times. Stand up. Try to walk across the room. It is a good idea to have friends around to catch you if you fall. Probably

you will see the whole room tipping to one side or another at a sharp angle. As you try to keep your balance on the steep slope your antics will be highly amusing—to others.

If you can persuade someone else to try the same experiment, watch his or her eyes. You will find them swinging rapidly from side to side. This motion is called *nystagmus.*

Some psychological laboratories have chairs so made that they can be whirled around and around. The subject of an experiment sits in the chair. The experimenter whirls the chair rapidly for a few turns and brings it to an abrupt stop. He observes the *nystagmus* and records the extent of it and the time until the eyes come to a natural rest. To the subject it seems that all the world is whizzing by him at such a speed that it is all a blur. Gradually the world slows down until things look natural once more. If the subject puts his head on his knees while the chair is whirling, and sits upright as soon as it comes to rest, the chair, the room, and all the world seem to tip up at an alarming angle. He naturally struggles to right himself. I almost managed to climb out of the chair in one such test!

The movements of the eyes and the distorted appearance of everything in the field of view prove that there

are connections by way of the brain between our semicircular canals and our eyes. There are connections, too, with the vital organs in the interior of the body. Severe dizziness may bring on nausea and vomiting. No one knows all the reasons why people become seasick, car-sick, or air-sick, but disturbances in the action of the canals, the nerves running from them, or the vital organs connected with them, are certainly a large part of the story.

Professional dancers can whirl around and around, until spectators are almost dizzy watching them—and come out facing the audience and perfectly steady on their feet. Aviators can bring their planes down in close spirals, and straighten out at the right level and in the right direction. Most persons who spend much time at sea soon acquire sea legs—that is, the ability to keep their balance even when the ship is rolling or pitching with some violence. Not everyone, though, becomes free of seasickness. Even some sailors are sick whenever the weather is really rough. If their sickness is severe enough to interfere with their duties, of course, they cannot continue to be sailors. Chronic seasickness is a recognized ground for honorable discharge from the navy.

A number of other sensations are grouped together in a vague miscellaneous group called somesthetic, or body

senses. Thirst is a dryness of the membranes of the throat. Hunger is pain caused by the contractions of the stomach. There are other sensations of fullness or strain. The intestines, odd as it may seem, can be cut or burned without pain but are very sensitive to stretching or bending. Nausea is a sensation with which we are all familiar, but which is very difficult to describe. Another such sensation is suffocation.

It must be evident by this time that we have many more than the traditional five senses—seeing, hearing, smelling, tasting, and feeling or touch. The sense of touch, we have seen, breaks up into pressure, temperature, and pain. We must also reckon with the muscle sense, the sense of equilibrium, and the large, vague group of body senses. Just how many senses we want to list is to some extent a matter of taste or convenience. Some investigators will want to group a number of sensations under one head. Others will insist upon breaking up the groups. Even the sense of sight might be thought of as two, a sense of light and dark and a sense of color.

Hunger is in most cases a sign that we need food, thirst that we need water. But it is important to remember that this is not always true. It is possible to be hungry when we are really well nourished, and thirsty in spite of the fact that the body tissues are well supplied with water.

It is also possible to feel no hunger, even though we may be in great need of food. Thirst, too, may be diminished or completely abolished—temporarily—even though the need for water may be severe.

When persons go for several days without food, their stomachs frequently adjust themselves to the absence of food, and there is no feeling of hunger at all. I once fasted for seven days. After the third day the experience was not disagreeable. I lost weight and strength, but I was not hungry. I could pass a table loaded with good food, at which people were happily eating, without a pang of hunger. Even the smell of food would produce only a mild hunger spasm.

On the other hand, injecting a small quantity of blood drawn from a starving dog into the circulation of a dog that has just finished a hearty meal will cause the well nourished dog to jump up and start eating again. It seems reasonable to conclude that insufficient nourishment causes the body tissues to contribute some definite substance to the blood. This substance, we may believe, stimulates the nerves that cause the muscles of the stomach to contract.

Suggestion, mere ideas, play a part, too. Some experiments on hens have been both amusing and instructive. Some hens were fed until they had eaten all the grain

they wanted. Then they were offered some of the same grains but of a different color. They began eating again and kept on eating for a long time. Again, hens that had eaten their fill were placed in a pen with other hens that had just begun to eat. They set to work just as though they were intensely hungry. Even the amount of food in sight had much to do with the amount eaten. The hens ate more if the pile of grain was large than when it was smaller.

The hens were very much like all of us. It is plain that there is much more to hunger than just our need of food. We eat heartily when we are cheerful. Bad news takes away appetite. So does worry. The surroundings in which food is served, the appearance of the food itself, the quality of the companionship and of the conversation, all have their bearing upon the enjoyment of our meals, the amount eaten, and the processes of digestion.

Thirst may be abolished for a time by spraying or painting the throat with some anaesthetic such as cocaine. Many athletes chew gum during contests. This stimulates the flow of saliva that keeps the throat moist. Lime drops or even a small smooth cool pebble under the tongue also help. On the other hand a dose of atropine will cause intense thirst, no matter how much we may have drunk immediately before it. That is not because the body as a

whole needs water. It is because the drug stops the secretion of saliva and so leaves the throat dry. Starvation may be painless after the first few days, but prolonged thirst is one of the most excruciating torments the human body can suffer.

CHAPTER IV

TASTE AND SMELL

THE NEXT time you have a severe cold, use it as an opportunity to make a little experiment. Notice how different almost everything tastes. Scarcely anything at such a time tastes right.

If you carefully compare the tastes of various foods and drinks when you are in good health and when you are suffering from a cold, you can easily convince yourself that the difference is one of smell. Many tastes, or what most people think are tastes, are really not tastes at all, but smells. Vanilla is one. The next time you taste vanilla ice cream, be very careful not to breathe while you are tasting it. Notice what you taste. It is only the sweet, the sugar. As soon as you breathe naturally again, the vanilla flavor comes back. Vanilla, you can easily prove to yourself, is a smell.

Finely chopped onion tastes the same as finely chopped apple! The difference is entirely one of smell. To prove that, we should have to shut off the sense of smell more

completely than any ordinary cold does. When psychologists experiment with taste, they stuff a subject's nose with cotton. They may even go so far as to spray the inside of the nose and the back of the throat with an anaesthetic to deaden the nerves. The subject is also blindfolded so that he cannot see what is being given to him. When such precautions are taken, a subject really cannot tell the difference between onions and apples. The taste of coffee is only bitter. You could not tell it from a weak solution of quinine. The best part of it is its delicious smell.

You may find it difficult to believe, but it is true that castor oil has scarcely any taste. If you have the courage to make the experiment, swallow a little of it while you hold your nose tightly. You will not taste anything very strong or disagreeable. After you have swallowed it, a little is sure to stick to your tongue and to the sides of your throat. As soon as you breathe again, you will smell it. Cod liver oil is another oil with very little taste but a strong smell that most people dislike intensely.

There are many tastes, but careful studies and experiments have clearly shown that they are all made up of four simple or elementary ones. The elementary tastes are sweet, sour, salt, and bitter.

The mention of salt naturally suggests pepper. But

pepper is not a taste. The hotness of pepper is like any other hotness. We have learned that "hot" is a blend or mixture of warm, cold, and pain. Pepper, even though it may be cool, rouses the temperature and pain nerves in the tongue so that it seems hot. The same thing is true of all the spices—ginger, cinnamon, nutmeg, cloves, and so on. They give us very little real taste but strong smells and sensations of warmth and pain.

There are other substances that taste cool. Peppermint is one. Wintergreen is another. When these are dissolved in the saliva and touch the nerve endings in our tongues, they rouse the nerves to report cold. Both peppermint and wintergreen also have a strong smell. Menthol is very strong peppermint. You know how cool it makes your throat feel.

When we taste lemonade, we are really tasting only the sweet and sour. We smell the lemon odor. We feel the cold and the wetness. If we add a little carbonated water, we shall get a sting. That sting is pain. A little pain, we have already remarked, does not hurt. Without it many drinks would taste flat. Just drink some ginger ale or some other fizzy drink after it has stood for a long time and has ceased to fizz. Probably you will not like it. It is too flat.

We taste sweet best with the tip of the tongue. That is

why we like to lick ice cream cones and sweet things generally. Sour we taste on the sides of the tongue, salt on the middle, and bitter at the back. Perhaps you can remember a time when you burned your tongue. For some days afterward nothing tasted right. If you ever have that misfortune again, notice what part of the tongue is burned and what tastes are blunted.

For experiments at home you can use sugar for sweet, lemon juice for sour, salt, and a piece of unsweetened chocolate for the bitter. Can you separate the lemon smell from its sour taste? Can you distinguish the chocolate smell from its bitter flavor? Can you note the different sensitiveness of different parts of the tongue to the various flavors?

For careful experiments we take a number of camel's-hair brushes. We dip them into solutions of sweet, sour, bitter, or salty substances, and paint the solution on one part or another of the tongue. The subject reports what he tastes. Between every two trials he should wash out his mouth to make sure that the old taste is gone and that it will not mix with the new.

We have not been so successful in discovering definite elementary smells as we have in the case of tastes. The best we have been able to do has been to list a large number of odors in certain large groups or classes. For ex-

ample, these odors seem to belong together: fennel, sassafras, marjoram, nutmeg, anise, pepper, cinnamon, cassia, cloves and caraway. Probably you know most of them. It seems reasonable, also, to list the odors in just about the order given. Each seems a little spicier than the one before it.

Bay smells much like caraway. We might go on to list hops, thyme, arnica, lavender, and vanilla. In this list we move farther and farther away from the spicy smells, and we seem to be moving in a different direction from that which we were following a moment ago.

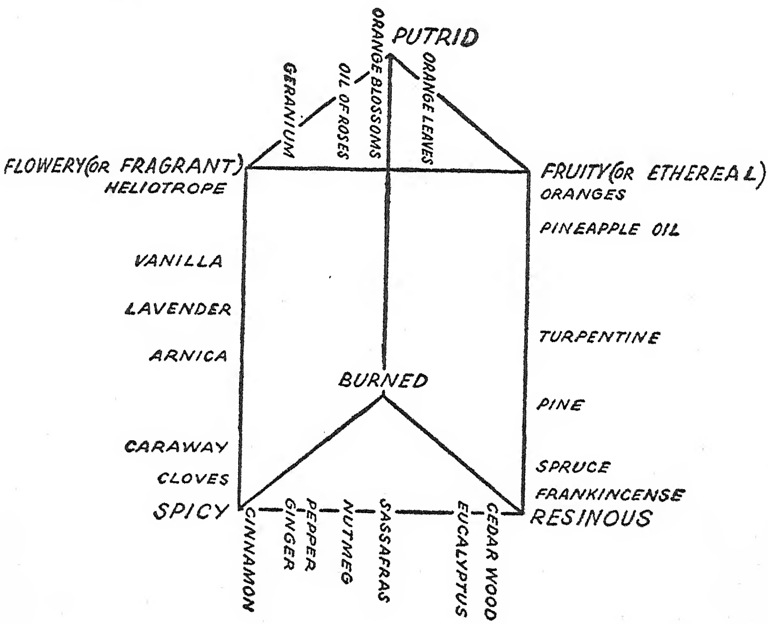
A third series runs: heliotrope, geranium, jasmine, oil of roses, orange blossoms, orange leaves, and orange oil.

A fourth would contain: lemon oil, strawberry oil, pineapple oil, ether, and acetone.

A fifth would be: turpentine, pine, Canada balsam, spruce, mastic, frankincense, cedar wood, eucalyptus, myrrh, and juniper.

Juniper is very like the fennel with which we started. So it seems that we could arrange all these odors in a circle. A German scientist by the name of Henning believed it would be best to arrange them in a square. That was because his subjects, as they smelled their way through the series, felt that at certain points they seemed to turn a corner or to start off in a new direction. Some new qual-

ity seemed to be coming in, and an old quality dropping out. Just where the corners ought to be located, or how many of them there ought to be, was very difficult to determine.



An illustration shows the smell prism that Henning finally worked out to classify all the possible smells. The corners, you see, are marked flowery, fruity, spicy, putrid, resinous, and burned. The table on page 46 gives a few of the odors near each of the corners.

Flowery (or Fragrant): vanilla, heliotrope, geranium, jasmine.
Fruity (or Ethereal): orange leaves, orange oil, lemon oil.
Spicy: ginger, cinnamon, cassia, cloves.
Putrid: rotten eggs.
Resinous: spruce, frankincense, cedar wood, eucalyptus.
Burned: tar.

These and many other smells we can think of as arranged along one or another of the nine edges of the prism. On each of the three square faces, moreover, we can draw two diagonals. From putrid to spicy the series would run about like this: rotten eggs, rotten cheese, mustard oil, horse radish, onion, garlic, asafoetida, celery, leek, parsley, and dill. The smell of tomatoes lies between the putrid and the flowery (or fragrant). The odor of fish scales would be placed somewhere between putrid and resinous. Altogether we can draw fifteen lines along which we can arrange odors. It seems as though we ought to be able to find a place for nearly all of them. If some are left over, we may locate them in the middle of one square or another, or in the interior of the prism.

Among the smells that seem to be left over is that of ammonia. The smell of ammonia, however, is almost entirely pain. Chlorine, bromine, iodine, and nicotine are

other smells that are principally pain. Camphor, menthol, carbolic acid (phenol), eucalyptol, and sassafras all smell cold. The smell of chloroform, bromoform, iodoform, and ethyl chloride is largely a sweet taste. Many acids smell sour. Alcohol generally smells warm.

If you come into a closed room in which a number of persons have been sitting for some time, you may find the odor and the stuffiness almost overpowering. Those who have been sitting in the room have not noticed it. If you force yourself to remain in the room without opening the windows, you soon cease to notice it yourself. The sense of smell shows even more adaptation than the temperature sense. Workers in tan yards, leather factories, slaughter houses, fertilizer works, and sewers never notice the smells that newcomers find almost unbearable.

Chemists have estimated that there are about 60,000 odorous substances. Some of them are extraordinarily powerful. Geraniol will attract Japanese beetles from distances of a mile or even more. When these dreaded pests arrive, they find a tempting meal of poisoned molasses waiting for them. Camphor can be detected by persons with an average sense of smell when there is only one part of it to 400,000 parts of air. Musk is even more powerful. One part of it in 8,000,000 parts of air will make itself known. Perhaps the most powerful of all odorous sub-

stances is mercaptan. It smells something like rotten eggs. This can be detected when the concentration is as low as .000,000,000,000,043 gram in one cubic centimer of air! A great French chemist believed, however, that the pleasant odor of freshly turned soil was due to an unknown substance something like camphor with such a powerful fragrance that even one trillionth of a milligram (.000,000,000,000,001 gram) gives a perceptible odor.

A great part of the world's business has to do with supplying food and drink. Taste and smell plainly have much to do with our liking for particular foods and drinks. So it is plain that anyone engaged in manufacturing either must give very careful attention to the taste or the smell of the product he hopes to sell. And it is plain, finally, that there must be expert tasters and smellers. Indeed tasting and smelling can almost be called professions.

The most highly paid tasters are those who sample wines. Salaries for real experts have run as high as twenty-five thousand dollars a year. Such men can recognize thousands of wines by their taste. They can tell not only the name of any wine offered them but in many cases the year in which it was made.

Our government employs a few tea tasters. These men set the standard for the teas permitted to enter the coun-

try. The jobs are under the Civil Service Commission. Requirements for a position—whenever a vacancy arises—are a delicate palate, five years in study and practice, and temperate habits. Teas are described as brisk, full rich, thick, insipid, grassy, fishy, smoky, flavory, harsh, metallic, acrid, puckery, toasty, malty, or brassy.

Tasters are also employed in the Bureau of Agricultural Economics to sample baked and canned foods, in the Food and Drug Administration for canned foods, vegetables, and coffee, in the Bureau of Animal Husbandry for meats. Coffee to many people is only strong or weak, good or not so good. The coffee experts use such adjectives as harsh, soft, sweet, sour, acid, winy, earthy, or hidey (like hides). Large department stores also employ tasters. Some of these are sent on long trips, often to foreign countries, to report on new delicacies. There are even soap tasters!

A few people make a good living by smelling. Manufacturers of perfumes are always experimenting with new ingredients, new mixtures, and new methods. They must have expert smellers who can tell them just what difference each change makes and who can check the materials and the work at every stage. One leading firm employed at one time fifteen such experts. Another firm insured the nose of its chief smeller for fifty thousand dollars.

A common way of testing perfumes is to dip a blotter

into a mixture of alcohol, water, and the perfume to be tested. The blotter is aired for one or two days. Then it is submitted to the expert.

In the last few years business men have given more attention than formerly to odors. There are today recognized odor engineers. A large part of their work is to get rid of the strong unpleasant smells associated with certain manufacturing processes. It has been found that odors influence our attitudes and our behavior in ways which are frequently so subtle that we do not realize what an important part the odors play. The sales of many products have been increased merely by improving their odor. The objectionable smell has been removed from raincoats. Shower curtains are treated so that they give a pleasing fragrance when water strikes them. There are spicy smelling pencils and scented typewriter ribbons and carbon papers for the office. At least one bus line and one railroad have been experimenting with perfumed gasoline and Diesel oil. It is easier to sell a house if it smells of varnish and fresh paint. On the other hand almost odorless paints are being welcomed by hotels, hospitals, and other buildings where every day's loss of rent is a serious matter. As for hospitals, the suggestion has been made that some smells might have a definite curative value. Some are known to be quieting, others exciting.

A fire insurance company got good results by using stationery that smelled of wet, burned wood. Many banks spray paper money with a perfumed antiseptic before putting the bills back into circulation. A very little cedar oil or some other aromatic may be the reason why the laundry returned from one particular establishment smells "so nice and fresh," just as though it were dried in the sun. Scents have been spread through movie theaters to make the scenes more realistic. There could easily be the scent of new mown hay, of violets, or almost anything you please, while the drama on the screen was taking place in such a setting. It is said that the effect is very marked. It is difficult, however, to spread the scents evenly and quickly over the whole of a large room and to change them everywhere at just the right time. We might add to this list of new uses for odors that one specialist succeeded in making sponge rubber smell exactly like cheese. That provided a rat bait that could be used over and over again.

Some women were asked whether they liked perfumed stockings. Nearly all of them replied emphatically that they did not. A little later each woman was permitted to choose one pair of stockings from a large assortment. They did not know that all the stockings were of exactly the same manufacture and quality. Some of the boxes in which the stockings were packed, however, were very

faintly scented. Fewer than ten per cent of the women chose the unscented stockings. Men, it may be worth while to note, are scarcely less sensitive. Very few men will buy an unscented shaving soap.

Many persons have observed that odors may arouse extremely vivid memories. A number of years ago I visited London. As I stepped out of the railway station, the peculiar smell of London brought back with almost staggering force a flood of memories of an earlier visit when I was a little boy.

Odors often produce surprisingly powerful emotional effects. There is a story that the poet Goethe once went to visit his friend Schiller. Schiller at the time was out. Goethe decided that he would wait. He sat down at Schiller's desk to do some writing. Very soon he felt oppressed, almost at the point of fainting. He called to Frau Schiller. When she came, he told of his distress and said that it seemed to be due to some strange odor. Frau Schiller went to her husband's desk and removed a number of rotten apples. Then she explained that her husband was powerfully affected by the scent of rotten apples and really could not do his best work unless he could enjoy it. Individuals are often peculiarly sensitive to the scent of some particular flower or to some particular perfume.

CHAPTER V

HEARING

For an experiment that will show you very convincingly what sound is, all you need is a spoon and a piece of string. Tie the string around the spoon so that the spoon is near the middle of the string. Wrap the free ends of the string around a finger of each hand. Now swing the spoon until it hits some hard object, say the end of a table. You will probably hear a slight ringing sound. While the spoon is still ringing and swinging freely, put the fingers around which you have wrapped the ends of the string in your ears. How different the spoon sounds! How strong and rich the tone is!

When the spoon struck the hard object, it was set trembling—or vibrating. The vibrations of the spoon set the air around it also to vibrating. It was these vibrations carried by the air that you heard as the ringing sound. When you put your fingers in your ears, the vibrations were carried by the string. They made your fingers tremble. The tremble was so slight that you could not feel it at all

in your fingers, but it was enough to make your ears vibrate together with the spoon. The vibrations carried by the string and your fingers were much more powerful and effective than those that came through the air. That is why the sound seemed so much louder.

There is another very easy experiment that is perhaps even more convincing. The next time you play a record on a phonograph, lift the needle off the record. Take a common toothpick between your teeth. Touch the other end of the toothpick lightly to the record as it turns. Note how clearly you hear the sound. Yet not a sound is coming through the air to your outer ear.

The record is simply a great many notches in a long spiral groove cut into a disk of wax. You can almost see the notches with your naked eyes. With a low power microscope—even with a good reading glass—they are clearly visible. As the disk turns, the needle is forced to swing rapidly from side to side. The needle is fastened to a thin, light plate. The plate, of course, vibrates with the needle. This sets a small column of air into vibration. The horn of the phonograph makes the small column into a large one and releases the vibrations to the surrounding atmosphere. The vibrations in the air reach our ears. The resulting sensations we call sounds.

When you removed the needle and substituted the

toothpick held between your teeth, the vibrations were passed on to your teeth. These passed the vibrations on to the bones of your skull. Through the bones the vibrations made their way until they reached the structures of the inner ear.

Perhaps you have given talking cards to some of your friends or have received some yourself. These are cards that say "Merry Christmas" or "Get well quick," or express some other cheery greeting. The important part of all such cards is a long, thin strip of metal roughened in a very particular way. A ring of light wire is also provided. If you pull the wire ring rapidly over the roughened metal strip, the card to which one end of the strip is attached will "talk."

If you pull the ring very rapidly over the strip, you will hear the words in a very high tone. If you pull it more slowly, the tone will be lower. If you speed up a phonograph record, you will raise the pitch of all the sounds. If you slow it down, the pitch drops lower.

All these experiments show us that sound is the result of vibrations that reach our ears; that these vibrations may travel through air or any other material; and that the pitch of a sound, that quality of sound which we describe as high or low, depends upon the rapidity, or frequency, of the vibrations.

The vibrations that we hear as sound travel through still air at a speed of about 1,130 feet each second. In water sound travels about 5,000 feet per second, and in a steel rod about 15,000 feet. Scientists have arrived at these figures by timing echoes, by noting the flash of cannon and the time that elapses before the sound is heard, and by timing with the aid of electric devices the passage of sound through city water pipes. If you have ever sat in the bleachers at a big league baseball game, behind the outfielders, you must have noticed every time a long fly was hit that the ball was well on its way before you heard the crack of the bat.

Sounds are commonly classified into noises and tones. Noises are very complicated sounds made up of many vibration rates all jumbled together. Tones are relatively simple sounds, with one or only a few vibration frequencies. All tones have pitch and loudness.

If you strike the keys of a piano, moving steadily from your left to your right, each note will sound higher than the one before it. Perhaps the reason we describe tones as high or low is that when we sing, we feel the vibrations of the low tones in the chest, of middle tones in the throat, and of high tones in the nose or throat. Perhaps you have heard someone say of a singer with a very deep bass voice that his voice seemed to come all the way from

his boots.

The quality that we describe as high or low, we have already remarked, we call pitch. We have already noted that it depends upon the frequency of the vibrations. Low tones have fewer vibrations than high ones. The lowest tones anyone can hear are about 12 vibrations a second.

It is easy enough to make instruments that will give 8 or 6 or even fewer vibrations a second. Giant tuning forks have been constructed with prongs five feet long and weighing two hundred pounds! You can easily make a simple vibrator yourself. All you need is a strip of brass or iron and a clamp by which you can fasten it firmly to the edge of a table. The strip should be about one foot long, one inch wide, and $\frac{1}{16}$ or $\frac{1}{32}$ of an inch thick. The clamp should be of a kind that will permit as much of the strip as you wish to project above the table edge and vibrate freely. If you clamp the metal strip to the table, bend the free end a little, and let it go, it will vibrate vigorously. The longer you make the vibrating part of the strip, the slower will be the vibrations. You may be able to get them as slow as four or five to the second.

Another way to produce low tones is to use very long pipes. In general, the longer an organ pipe is, the lower is its tone. Some organ pipes have been made more than sixty feet long.

If you hold your ear close to a giant tuning fork—or your home-made vibrator—you will find that you cannot *hear* anything if the vibrations are less frequent than about ten to the second. You will *feel* little puffs of air like so many very rapid bumps. When the vibrations reach ten to the second, the bumps begin to fuse together. At twelve per second most persons say they distinctly hear a very low tone. The lowest note on the keyboard of an ordinary piano is about 27 vibrations a second. The lowest tones we can hear, then, are about an octave below the lowest tones of our pianos.

Low tones, when they are at all loud, sound large, majestic, and solemn. They seem to shake us, even to shake the building in which we may be. Sometimes they produce powerful emotional effects. There is a story of a moving picture theater manager who found that one of his pictures was proving a disappointment. In the theater there happened to be an enormous organ pipe, so huge that it would give only two vibrations a second! At a certain tense moment in the picture he put this great pipe into action. The effect was greater than he had planned for. The entire audience was overcome with terror. To a man, they rushed out of the theater into the street! Two vibrations a second is far too low a frequency to be heard at all. But it was felt. And it was felt as something huge and

vaguely terrible.

As for the highest tones, individuals differ greatly. With a Galton whistle it is possible to produce tones of 40,000 or even more vibrations a second—but very few persons can hear them. You can get some idea of how high that is, if you will bear in mind that the highest note on a piano keyboard is only about 4,200 vibrations a second. Only a very high soprano voice can reach as high as 1,300 a second—high E.

The lower notes of the Galton whistle sound somewhat like small bird calls. As they go higher and higher, they seem to lose their quality as sounds. There is a region in which it is difficult to say whether one is really hearing anything or is only aware of an odd little feeling something like dizziness. Some persons report that they can hear frequencies as high as 30,000 or 35,000 a second. For many people the limit is about 20,000—about two octaves above the highest note of our pianos. As we grow older we lose the ability to hear the highest tones.

Dogs seem to be able to hear higher notes than human beings can. There are whistles on the market that give a tone too high for people to hear. Dogs, however, will respond to it.

Loudness depends upon the amplitude of the vibrations. That means the distance each tiny particle of air or water

or other material moves back and forth as it vibrates. The amplitude of sound vibrations is astonishingly small. For a very loud sound indeed it is only about $\frac{1}{10,000}$ of an inch! Now you can easily understand why you could not feel the vibrations of the spoon with your fingers. Your ears, of course, are very much more sensitive than your finger tips.

You can feel the vibrations in your fingers, however, if you touch the sounding board of a piano, or the wooden body of a violin or cello, while any of these is being played. You can even obtain such sensations from the loudspeaker of a radio. Helen Keller, who is both deaf and blind, has written that she can enjoy a concert, if she can place her fingers on the vibrating portion of a radio. A few musicians who have lost their hearing have reported that they got real enjoyment from the vibrations felt in their feet or in the chest cavity while a concert was in progress.

To measure the loudness of sounds accurately very complicated instruments are needed. With only a metal ball, a yard stick, and a board, however, you can work up an experiment to show roughly what small differences in loudness you and your friends can distinguish. Simply lay the board flat on the floor and drop the ball on it from different heights. Use the yard stick to measure heights.

The farther the ball falls, the harder it will hit the board, and the louder will be the sound.

One way to carry on the experiment would be to say to a friend, "Sit with your back to me. I will drop this ball on this board twice. Tell me whether the second sound is louder or softer than the first." Begin with 12 and 13 inches. Mix up the order in which you drop the ball, so that half the time the 13 inch drop is second, and the other half of the time the 12 inch. Make from ten to fifty such trials. Then try 12 inches and 14 inches in the same way—and so on. What was the percentage of right judgments for each difference? How great a difference is necessary before judges can be right ¾ of the time or all the time? Do your subjects differ very much in their ability to judge these differences in loudness? Are boys better than girls? Are grown-ups better than children? Are musicians better than others who are not musicians? Does practice make your subjects better judges?

This very simple way of comparing the loudness of sounds was used in some of the early studies of sleep. It was found that it took a much louder sound—that is, the ball had to be dropped from a much greater height—to awaken a sleeper after about one hour of sleep than at any later period. Investigators concluded that sleep was deepest during the first hour and that it grew steadily less

deep as the hours passed. Later studies with much better apparatus and improved methods have yielded the same conclusion.

There is more to tones than pitch and loudness. There is another quality for which there is no English word. To denote it we use the French word *timbre*. You can sing Oh and Ah, and EE, and OO all on the same pitch and with the same loudness. The quality in which they differ is what we call their *timbre*. Just as there are differences between vowels, there are differences in *timbre* between voices or the tones of musical instruments. A large pipe organ contains many pipes that give tones of the same pitch. They differ in *timbre*. The possible combinations of tone qualities run into the thousands.

The *timbre* of a tone is the result of additional tones much weaker than the main one and combining with it so perfectly that we can hardly recognize them as separate tones. The main tone we call the fundamental, the lesser ones we call overtones. You can easily demonstrate some overtones on the piano. Press the keys C and G very slowly and lightly, so that you raise the felts from the wires without letting the hammers strike. Now strike vigorously the note C one octave below the C you are holding down. Allow the note to sound for some time. Release the key, allowing the felt to silence the sounding wire.

You will hear the higher C and the G above it still sounding. They were overtones of the lower C. With a little practice you can hear them in the lower tone without having to separate them out as you did at first. There are other overtones, too, but they are too faint to be shown in such a simple fashion. You may be able to hear some of them if you hold down a great many of the keys with your arm or with a yard stick. You can roughly analyze some of the tones of your own voice if you will press down on the loud pedal, thus raising all the felts, and sing a note right into the piano. When you stop, you may hear several of the piano wires sounding.

Tuning forks give very pure tones—that is, tones with only one vibration frequency. Such tones are beautiful, but music would not be nearly so rich, varied, interesting, and exciting as it is if we had only such pure tones with which to work. The differences between human voices, all the rich colorings that our many musical instruments provide, are due to the different combinations of overtones.

Radio and telephone engineers, sound directors of moving pictures, and architects who design public halls find it very important to be able to measure the loudness of sounds. Remember that the loudness of a tone depends principally upon the energy or power of the vibration.

In a perfectly still room, with all noises from outside eliminated, we can hear amazingly faint sounds. On the other hand, we can endure very intense sounds indeed. In terms of energy the loudest sound we can endure is about a million million times the faintest sound we can detect.

If we compare one tone with another of the same pitch but a little louder, we find that there must be a difference of about 26% in the energy or power before we can distinguish between them with any certainty. The next louder tone would have to be 26% greater in energy than the second, and so on. It is common practice to call this just noticeable difference a unit of loudness. Ten such units we call a *bel*—after Alexander Graham Bell, the inventor of the telephone. Each unit is therefore a *decibel.* The count is understood to begin with the faintest sound that can be heard.

A sound of 50 decibels would then be fifty units louder than the faintest sound we could hear. That would mean that its energy or power would be 100,000 times that of the faintest sound. The table below gives some rough measures of common sounds. It is taken from a number of sources.

	Decibels
Painful sounds	130–140
Airplane engine	110
Boiler shop	105

HEARING

	Decibels
Riveter	100–110
Elevated train	90
Heavy street traffic	80
Niagara Falls	70
Busy street	70
Ordinary conversation	65– 75
Average office	38
Quiet office	30
Whisper	10– 20
Rustle of leaves	8
Limit of hearing	0

CHAPTER VI

SEEING

SCIENTISTS are not quite sure whether light is a matter of waves or of tiny corpuscles shot off in every direction. It seems to have some of the characteristics of each process. So there is a wave theory of light and a corpuscular theory. Some day we hope we may be able to combine the two theories into one. Already we have begun to speak of "wavicles" or tiny packets of waves that act something like particles.

If light is a matter of waves, moreover, we want to ask, What waves? In what do the waves travel? No one can tell us with any certainty. Not very long ago scientists believed that there was an ether, like a very light fluid or gas, filling all space. The waves of light traveled through this ether very much as other waves travel over the surface of water. Recently scientists have found many reasons to doubt that there is any ether. They are inclined to believe that the waves are crumplings of space itself.

We must leave such problems to students of physics.

The properties of light that concern us as students of human experience are properties of waves. And we can get along very well without asking what it is that waves.

The waves with which we have to deal are almost unbelievably small. To measure them we have to use millionths of millimeters. A millimeter is a thousandth part of a meter. It is very nearly $1/25$ of an inch. A thousandth part of a millimeter is called a micron. A thousandth part of a micron we call a millimicron. The longest light waves we can see are about 760 millimicrons. The shortest are about 390 millimicrons.

Though the waves are so very tiny, their velocity and frequency are enormous. Light travels at 186,000 miles or 300,000 kilometers a second. The frequency of the vibrations is hundreds of trillions every second. Five hundred trillion would be written 500,000,000,000,000. It is almost terrifying to think that all space is filled with hundreds of trillions of vibrations every second, traveling 186,000 miles a second, and that objects all around us are catching these vibrations and hurling them back into space.

The frequency and the wave length of light waves are very closely related. When we were dealing with sound, we spoke principally of the frequencies. In the case of light the frequencies are so enormous that it is more con-

venient to speak of the wave lengths measured in millimicrons.

A triangular prism of glass will take a beam of ordinary sunlight and spread it out in a way that shows the many different colors that make it up. This band of color from red to violet is called the sun's spectrum. Drops of water in the air after a rainstorm do the same thing on a very large scale, though not so sharply and distinctly as a well-constructed spectroscope. The result is a rainbow. If you have ever taken a trip in the Maid of the Mist, the little steamer that runs close up to Niagara Falls, you must have seen rainbows in every direction, often in complete circles. They are due, of course, to the drops of water in the air.

The long waves, those close to 760 millimicrons, give us red colors. Waves of about 580 millimicrons give yellow, 520—green, 480—blue, and 390—violet. It is important to remember that this range of visible light is only a narrow band in the whole range of vibrations of which we have knowledge. Beyond the red end of the spectrum are the infra-red rays. Those carry heat. (I once ate a steak that had been cooked—so the advertisement stated—by infra-red rays.) When specially prepared plates are used, infra-red rays yield very clear photographs. So it is possible to photograph persons and objects in a totally

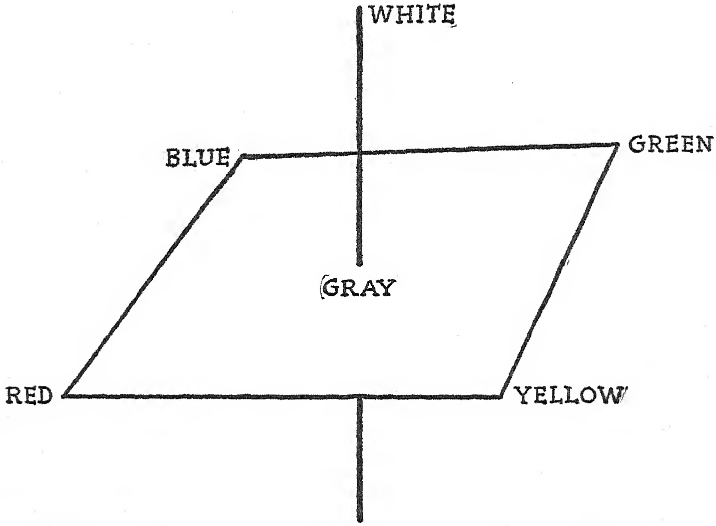
dark room. There are many possible uses for the infra-red rays—in detecting crime, in providing warning of the approach of ships in fogs, of airplanes at night, for sending of secret messages, and so on. Beyond the violet are the shorter ultra-violet rays that do not stimulate any sense organ in our bodies but do tan the skin and may produce severe burns. Beyond these lie the X rays, and beyond them still others, until we come to cosmic rays, with wave lengths of about .000,000,000,01 millimeter.

The average human eye can distinguish about 35,000 color qualities. Imagine that we had 35,000 little cards, each of a different color. How ought we to go about it to arrange them in some kind of system?

Probably it would be best to begin with the grays. If we look carefully through our pile, we shall find nearly 700 of them! We can arrange them in a series up and down, running from white at the upper end to black at the bottom.

Now we may go to work on the other colors. Let us take the strongest, richest reds, yellows, greens, and blues that we can find. These, too, we can arrange in a series. Begin with red. We can find a red that is just a little yellower, then one that is still a little yellower. Soon we have orange. We can go on in this fashion until we reach a pure yellow.

We can go no further in this direction. So we will start toward green. When we reach a pure green, we shall have to turn again, this time toward blue. From blue the series turns back again toward red, and we have the various hues



of violet. The ordinary eye can distinguish about 130 steps in this series. The various colors seem to arrange themselves naturally in a square, with the corners at the pure red, yellow, green, and blue. This square we can place around our pile or column of grays, as shown in the illustration.

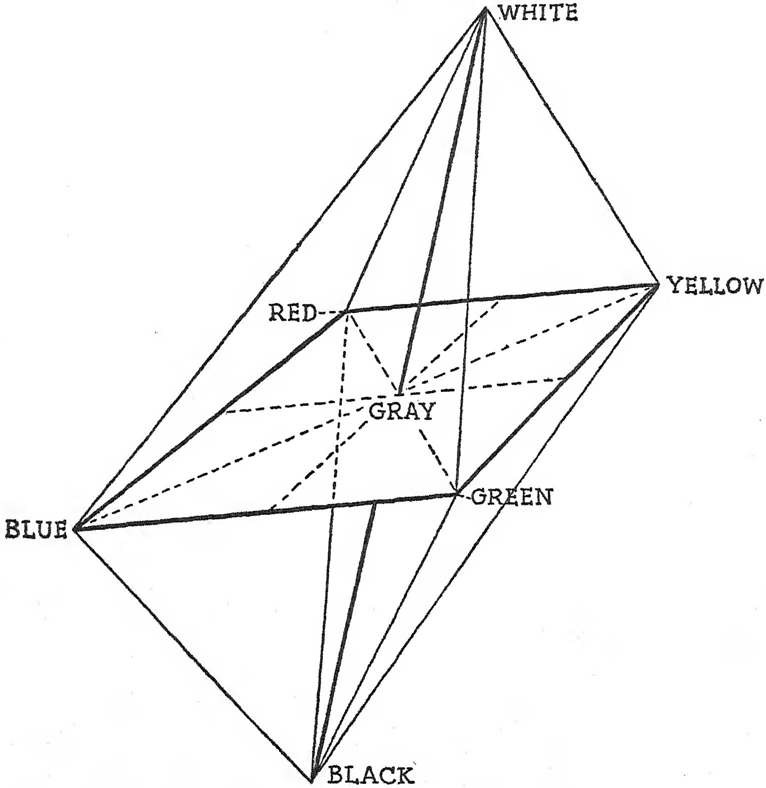
We call red, orange, yellow, green, and so on hues. Now notice that many of our color cards are of the same

hue as those we used to make up the square, but they are darker or brighter. We will put the brighter ones in order above each of the hues. The darker ones we will place underneath. Now we have a hollow figure very much like a long box without ends, with a rod through the middle.

If you should want to go from red to green, you could do so in either direction around the square. You can also do so through the middle. You can work by small steps from each hue to the gray in the middle, and from the gray out again to any hue we wish. You can do this at any level of brightness. So we shall have to fill the inside of our figure with colors of varying hues, tints, and shades to which is added more or less of gray. Now we have degrees of what is called saturation. A color is said to be highly saturated when it is as full and rich as it can be. A weak, washed out, or muddy-looking color is said to be of low saturation. Brown is a dark orange of low or poor saturation.

Now notice one more fact. Then we shall be finished with our classification of colors. The most saturated colors are those of medium brightness. Brighter and darker colors lose saturation. An extremely bright color is almost white, an extremely dark one almost black. So we ought not to build the sides of our figure straight up and down. Instead we should slope the sides, both upward and down-

ward, toward the center. This gives us a double pyramid. (See the illustration.) In this drawing the square is tilted.



This is done to show that when all the hues are at their highest saturation, yellow is the brightest and blue the darkest. In this figure the 35,000 possible color qualities are arranged (1) up or down according to their bright-

ness, (2) in positions around the square according to their hue, and (3) in and out from the center according to their saturation.

Like sound waves, those of light have amplitude as well as length, and the amplitude depends upon the energy at work. Corresponding somewhat to pitch, loudness, and timbre, colors have hue, brightness, and saturation. The hue depends upon the wave length (or frequency), the brightness upon the amplitude (or energy), and saturation upon its purity or its mixture with gray.

It is a little surprising that a few rather common colors do not appear in the spectrum at all. Spectral violet does not quite close the gap between blue and red. Between violet and red lie purple, magenta, and a number of similar colors. None of these colors appears in the spectrum. They are obtained by mixing blue with varying amounts of red. Indeed spectral red itself is not a pure red. It looks a little yellowish. To obtain the pure red we must mix a very little blue with it.

The mixing of colors presents a number of interesting problems. Some colors are plainly mixtures. In orange it is easy to see both the red and the yellow. Then there are the yellow-greens, the blue-greens, the violets, and the purples. In all of these the mixture of two colors is plain. They may all, except the purples, be produced in either of

two ways—by a single wave length in the spectrum or by mixing two wave lengths, one on each side of the one we wish to match. Thus orange appears in the spectrum but we may also obtain it by mixing red and yellow.

A few colors do not seem to be mixtures. These are red, yellow, green, and blue. That is why we took them for the corners of our color square. You may know that mixing yellow and blue paints will give green, but most observers agree that a pure, strong green does not look like either yellow or blue. Red, yellow, green, and blue we call the psychologically primary colors. The list is not complete even now. White and black, whatever we know about them, certainly seem to be as true colors as those we have mentioned, and just as primary or elementary. White certainly does not look like a mixture and black does not look like a mere absence of light—a hole, as we might say, in the field of vision.

The complete list of the psychologically primary colors, then, those that *look* primary or unmixed, is red, yellow, green, blue, white, and black. We can study the mixing of colors in at least three ways. One method makes use of the color wheel. This is only a disk on which we can fasten papers of any colors we please and which can be rotated rapidly either by hand or by an electric motor. It is easy to adjust the papers to give any proportions we

desire of the colors we intend to mix. When the disk is rotated slowly, we can still see the separate colors. As the speed increases, the colors flicker. A little faster yet, and the separate colors disappear. The whole disk appears one color, the result of the mixing.

Another way is to let two lights shine into the eye. This is a rather complicated and difficult kind of experiment. It is much easier simply to darken a room and project two or more beams of colored light upon a white screen in such a way that their circles overlap.

All three ways yield the same result. Some of the results are surprising. If we mix blue and yellow, you probably think the result will be green. No. The result is white—a yellowish white if the yellow is a little too strong, a bluish white if it is the blue that predominates. Red and green mixed in the same way give yellow. This yellow mixed with blue will give us white—or gray if our light is not strong.

You may find it a little easier to believe that blue and yellow really do combine to form white if you watch some white clothing after it has been well washed and before and after it has been dipped in bluing. Clean cotton cloth looks dingy and a little yellow. When it has absorbed just a little of the bluing, it comes out snow white.

Why, then, do blue and yellow paints, when they are

mixed, yield green? The answer is that both of them reflect green in addition to blue and yellow. The blue and yellow cancel out, and the green remains.

Mixing red and green paints gives a muddy brown. Brown is a dark, unsaturated yellow or orange. So in this case the result of mixing paints is very nearly the same as of mixing lights.

Some mixtures of colors do not yield an in-between color. Instead they give white or gray. Colors that combine in such a fashion we call complementary. We have seen already that blue and yellow are complementary.

About 3% of men and a very few women are more or less color blind. If the defect is slight, the individual may confuse only a few colors. I have known one such man to insist that a very pale green and a very light brown looked alike. In more severe cases the unfortunate person cannot tell the difference between red, yellow, and green. The world of color for such individuals seems to be made up of white, grays, blacks, yellows, and blues. Of course they cannot be trusted in any kind of work in which it is important to distinguish colors. Even the red and green lights on our highways look alike to them. In extreme cases all sensations of color disappear. To such persons the world must look very much as it looks to most of us in photographs or moving pictures.

A few persons have been found who are color blind in one eye and not in the other. They can tell us how things look to the defective eye. A red-blind person sees yellow, green, and blue just as we do. Red for him is one of the yellows. A green-blind person sees the green as yellow. One who is blind to both red and green must see them both as yellow.

CHAPTER VII

ATTENTION

There is an old story of a chameleon that illustrates a very important point for our understanding of experience. Placed on a green cloth, he turned green. On a red cloth he turned red, and so on through all the colors. Then a cruel practical joker put him on a Scotch plaid. That was too much. He blew up!

We are in contact with our environment through eyes, ears, and noses, through millions of tiny little sense organs in the skin, through other millions of little reporting stations in our muscles, tendons, and joints. Inside our bodies are still other millions of listening posts. From all of them messages are continually streaming in to headquarters—the brain. If all of these came to us on the same level of importance, if we had to respond to each one separately, we would all of us, like the poor chameleon, blow up.

We can act efficiently and live orderly lives, instead of blowing up, because we do not respond to every message separately or attach equal importance to all of them. The

first step toward setting up order in our lives is selection. We have to select some stimuli to which to respond in particular ways. Others we need only lump together in a rather indefinite mass; and it is usually sufficient to deal with them in some rough, general fashion. To some we respond automatically, mechanically, or without thinking. Others require very careful and active thought.

This selection of only a few of the many millions of stimuli reaching us, this concentration upon them, we call attention. It is something like the spotlight in a theater, that brings some person or object on the stage into prominence, leaving the rest as an indistinct background. As you read this, you are probably sitting in a chair. Have you noticed the pressure of your clothing against various parts of your body? Have you noticed the pressure of the chair? Probably not. Yet it is easy enough to do so, if you direct your attention to the right points. As an exercise, let the spotlight shift over your body from your toes to your head. Note the pressures. Note whether the muscles are tense or relaxed. Now begin reading again, but spare some attention for the muscles of your tongue, jaws, and lips. Do you notice them starting to frame the words you read?

What shall we say of the various stimuli to which we are not attending. We are not entirely unconscious of

them. We are aware of them, and we adjust to them, as a vague, dim background to whatever may be holding our main interest. Your muscles hold you in a certain position in your chair. If they were to relax completely, as they would if you should faint, you would slither out of your chair on to the floor. Even in sleep you adjust in some very important and really complicated ways to your surroundings. It surely is several years since you last rolled out of bed. That is because you learned early in life to take some kind of notice of certain pressures or the absence of such pressures, so that you do not roll beyond a certain point. Sailors in the navy after a few painful falls learn to sleep safely and well in hammocks.

The act of attending to any stimulus is largely one of getting ready. We get ready to receive the stimulus in the best possible manner and to do something about it. If it is something we wish to see, we turn our eyes, perhaps the whole head or the whole body, until the object is in the center of the field of vision. If we are listening to a sound, we may turn the head, or cup a hand back of one ear, to get the most effective possible stimulation of the ear. If we are trying to analyze a taste, we roll the substance around on the tongue. Along with these adjustments of our sense organs go other complicated internal adjustments that are not well understood. The effect is to nar-

row consciousness down to a small point. A few objects that hold the spotlight are very clear. Other things are noted only in a dim, hazy fashion or not at all.

Along with this narrowing of consciousness there usually goes a setting of the muscles to act vigorously and promptly. The runner on his mark waiting for the signal to start, the boxer looking for an opening or ready to block an opponent's blow, the soldier standing at attention to receive his orders, are all good illustrations. Sometimes the readiness seems to consist in going as far toward executing the intended response as one can without actually doing so. This seems to be the case with the runner. Sometimes he goes too far and starts before the signal. In other cases the readiness is of a more general sort, to do anything that the situation may require. We see this kind of readiness in the boxer or the soldier.

Consciousness is a matter of degrees. We are clearly, vividly, or intensely conscious of some things, less so of others, still less so of others. Of some others we are conscious only when attention is particularly directed toward them. Of some, finally, we are not conscious at all. To make use again of some illustrations used earlier, just now you are probably chiefly conscious of this page and the printed words on it. You are less conscious of the pressure of your clothing and of your chair against your body.

Most of the time you do not notice that you are breathing. Only rarely, if ever, do you notice the beating of your heart. Of many other bodily processes such as digestion, you are not conscious at all.

Life goes on somewhat like a large business. In any big company the manager has many subordinates, from his immediate assistants down to the office boys. Each has a range of duties. Each is expected to make certain decisions on problems that arise. It would be a serious mistake for the manager to concern himself with the smaller problems. He must save his time and his energy for matters that cannot be dealt with by fixed rules and that he cannot safely leave to his subordinates.

We should be hopelessly lost if we had to direct our various bodily processes—the beating of our hearts, the activities of stomach, liver, kidneys, and other organs. Fortunately for us, these go on almost mechanically. Some other matters we have learned to handle according to fixed—or almost fixed—rules. Our habits take care of them. Some habits are deeply and firmly set, and work with almost no thought. Others require a little thought. Finally there are sure to arise situations that we cannot fit into any of our rules. It is to these that we have to give our close attention and thought.

To see how we organize our activities at these different

levels, watch someone learning to drive a car. At first he has to give his whole attention to the operation of the various controls and to the road before him. Little by little the various movements necessary to guide the car require less and less attention or thought. He makes them easily, at the right time, almost automatically. A good driver can spare enough time from his driving, so long as no dangerous situations arise, to carry on conversation. He can even take his eyes from the road for several seconds at a time. Only when danger threatens or a difficulty arises, does he give his whole attention to his driving.

Individuals differ greatly in their tendency to concentrate their attention upon particular objects or to scatter it over many. Some become so absorbed in a problem or a task that they forget their surroundings completely, and it requires a very strong stimulus indeed to make them attend to anything else. It was said that Socrates stood one whole night in thought upon some problem that interested him. Archimedes, the great mathematician of Syracuse in Sicily, was so absorbed in some problem of geometry that he was unaware that his city had been stormed and captured by the Romans. When a Roman soldier appeared before him, he cried out, "Don't disturb my circles!" The soldier, instead of admiring such concentration, ran his spear through the mathematician—al-

though the Roman general had given strict orders that Archimedes was to be spared. It has been recorded that a Protestant student in Paris, Joseph Scaliger, was so deep in the study of Homer that he knew nothing of the frightful massacre of Saint Bartholomew's Eve, or of his own escape, until the following day. Isaac Newton sometimes forgot to dine. Soldiers in the excitement of battle have often failed to notice that they were wounded. And many a man or woman has been able to shut even severe pain out of mind for a time, while he or she gave every thought to the performance of some pressing duty.

Most of us, while we are attending to one matter are at least dimly aware of the things going on around us. At the other extreme from such examples of concentration as we have just been considering are others who seem unable to concentrate for any length of time on anything at all. I once heard the principal of a high school tell his students that he had often wondered why monkeys did not get further along than they did. After watching them for some time, he had come to suspect that one reason was their inability to attend to anything for any considerable time. Young children are very like monkeys in this respect. A French writer has remarked that a child seems to belong less to himself than to every object which happens to catch his notice.

If we reflect that monkeys and young children, and we may add the feeble-minded, are unable to give prolonged attention to anything, it should be plain that the reasons why we select some matters for our attention and ignore others are to be found partly in the objects and partly in ourselves. In objects, change, intensity, size, duration, movement, and repetition are commonly listed as qualities that catch and hold attention. If things remain the same, we soon cease to pay attention to them; but any change catches attention at once. It may be a change in motion—beginning or stopping some movement. It may be sudden sound or silence, or simply a sound of a new and different kind. There is a story of a soldier who was sleeping peacefully close beside a large and very noisy cannon. When his officer spoke to him in a very moderate voice, he promptly woke up. A loud noise, a bright light, a severe pain, all attract attention when less intense stimuli would be ignored. A large advertisement catches our eyes, while a small one would be overlooked. Obviously, too, it is necessary for most stimuli to work on us for some little time before they produce any noticeable effect. Railroad crossings now have moving signals to warn people that trains are approaching. Many trucks, buses, and private cars have moving signals of one kind or another to warn drivers behind them of stops or turns. That is because move-

ment catches attention. Finally, every advertiser makes large use of repetition. It is not enough to tell you once what kind of gasoline or soap or breakfast food you should buy. You might never notice it, or you might soon forget it. It is necessary to tell you over and over again.

There are other factors that are not quite so easy to define. Sometimes they are lumped together under the not very satisfactory heading "striking quality." High sounds have an advantage over low ones. Saturated colors get more attention than pastel shades. A pretty girl figures in many advertisements. Novelty and incongruity exert a powerful pull.

Attention is not so passive a matter, however, as all this might lead us to think. We ourselves have much to say, indeed in most cases we have the deciding voice, as to what shall occupy our minds. In general it is a matter of our interests and habits. If you are ever fortunate enough to take a walk through some woods with a botanist, you will be astonished at the number of things he will see that you will not notice until he points them out to you. It is not that his eyes are better than yours. It is simply because he is interested in plants and has developed habits of looking for them. An entomologist would see insects where no one else would. An ornithologist would identify birds. A geologist would notice contours of hills and valleys and

the outcroppings of rocks.

Habits of attention may persist even in our sleep. We have already noticed the case of the soldier asleep near the cannon who wakened when his officer spoke quietly to him. Another illustration is that of a doctor and his wife. The doctor would wake when the telephone rang, his wife when the baby cried. Probably many young doctors have worked out the same, or a very similar, division of labor.

The interests that determine how we shall direct attention may be permanent or only temporary. If you have been on a long automobile trip, you may remember that when it was about meal time you became more interested than usually in the various eating places along the highway. A girl about to be married notices such things as china-ware, mops, and garbage pails in store windows. A few months or even weeks before, she may never have given them a look. A mother notices displays of children's clothing of a kind or size that her own children might wear. A connoisseur of art or antiques quickly spots a treasure in a pile of rubbish. A gem expert sees at a glance qualities in a precious stone that an ordinary person may find it difficult to see even when they are pointed out.

Salesmen, advertisers, speakers of all kinds, teachers, and writers all must know how to catch and hold attention. It is not very difficult to catch attention for a moment.

Almost anything novel or startling will do the trick. To keep anyone's attention for more than a moment, though, it is necessary to arouse his interest. He must be made to feel that something important to him is about to happen, that it will make a real difference in his happiness which way things turn out.

The next time you read a particularly interesting story, give a little thought to the way the writer arouses your interest at the beginning. What was there in the first few lines or sentences that made you want to read further? How did the author picture the main character, so that you just had to see what happened to him—or to her? What long-time or short-time interest of yours did he arouse?

Do the same when you listen to a speech. Study advertisements. Then try to apply some of the principles in writing, in persuading your friends to do something you want them to do, in selling something—or in applying for a job.

Among the early experimenters upon attention was Sir William Hamilton of Scotland. His *Lectures on Metaphysics* was published in 1859. He was chiefly interested in the question of how many objects the mind could perceive at once. Some earlier writers had set the limit at four and others at six. Sir William's method was to throw a

handful of marbles on the floor, take a single quick look at them, and guess their number. He found that he could not judge the number accurately if there were more than six or seven. He noted, however, that if one grouped the marbles in twos and threes, or even fives, a much higher count was possible. That was because each group could be counted as a unit. One could then perceive almost as many groups as one could single marbles.

There is some evidence that practice will increase the number of objects we can distinctly see at a glance. You might find it fun to practice walking past a store window rapidly and a little later counting the number of objects you saw. Try it day after day and see how your score improves.

Distraction is perhaps as interesting a subject for experiment as concentration. There have been a number of experiments to determine the effects of distraction and how individuals resist it. In 1916 Morgan set a number of students to work on a rather difficult task. After they had worked in quiet for a time, bells, buzzers, and phonograph records began to sound from all parts of the room. Records were made of the amount of work accomplished, the breathing, and the muscular movements made. In general the students did somewhat slower work at the beginning of the noise but soon improved until they were doing

better than before. They put more energy into their movements. It was plain that the distraction called forth increased effort, and the increased effort resulted in better work than before the distraction began.

This experiment and others like it have shown that "distractions" do not always distract. It would be going too far, however, to conclude that to do our best work we should surround ourselves with noise or other nuisances. By intense effort we may be able to overcome the distraction, but the added effort may prove exhausting.

You can easily try an experiment of this kind yourself —or with others. Just take some simple task at which you can measure the work you do. For example, see how many times in a minute you can say the alphabet backwards, or how far you can go in adding alternately 7 and 9— or any other combinations. Try it first in quiet, and later with some kind of distraction. Compare the scores.

A number of experiments have made it clear that sounds and other stimuli which arouse one's interest, for whatever reason, are far more distracting than much more intense stimuli that are meaningless. Mere noise is not often very interesting. We can fairly easily learn to ignore it. Think of workers in noisy offices or shops in our large cities. After a little experience in such surroundings they cease to notice noises that are distressing to a newcomer.

Intense effort, we have seen, seems to shut out the distraction. The result, surprising though it seems, is sometimes better work—at least for a time. There is another way to overcome distraction, more difficult, but perhaps more effective. That is to take in the distracting stimulus, to welcome it, and to make it a part of the conditions for your very best work. One of my students once told me that his roommate had a particularly noisy typewriter. For weeks the typewriter had proved a very annoying distraction. At length he tried to make it a part of what we may call his work situation. When it began to clatter, he would say to himself, "There goes that good old typewriter; now I can get down to work." To his great relief and satisfaction this change in his attitude produced the desired results.

CHAPTER VIII

IMAGINATION

EXPERT chess players sometimes undertake to play blindfolded against a weaker opponent. This does not mean that the expert's eyes are actually covered. He may sit in another room, or simply with his back to the table. Someone tells him the moves his opponent makes, and he in turn directs the moves to be made with his pieces. The handicap consists in the fact that he must play without seeing the board. He must carry the game in his head. A former American champion, Pillsbury, once played against as many as twenty-one players at one time, and succeeded in winning most of the games! None of the players, of course, was Pillsbury's equal; but neither were any of them mere beginners.

Almost everyone claims to be able to see in imagination scenes at which he is not actually looking, and in the same way to hear sounds, taste flavors, smell odors, and feel pressures or pains or movements none of which are really present. The ability to do this we call imagination.

The mental pictures we call images.

Perhaps you do not play chess. If you play checkers, bring home from your local library a book on that game. See how far you can follow the games in the book without the actual board and men in front of you.

If that is too difficult, or not very interesting, try this one. Imagine a wooden cube three inches on each side and painted black. That is easy enough. Now imagine it cut into little cubes, each one inch on a side. That is not very difficult, either. Of course there will be twenty-seven of them.

Now imagine the twenty-seven little cubes all separated. If you will look carefully at them—it will have to be in imagination, naturally—you will notice that some of them are black on three sides, some on two, some on one, and so on. How many of the small cubes are black on three sides, on two sides, on one side, and on no sides? When you get the answer, compare it with the correct answer at the end of this chapter.

Some blindfold chess players have said that they can see the board in their mind's eye only a little less clearly than if they were actually looking at it. In their cases the handicap was probably very slight. Others insisted that they did not see the board at all. They knew that particular pieces were on particular squares and that from

these squares they commanded certain others. Though I am by no means an expert, I have tried a few such games myself. I found that I was obliged to use both methods.

Imagination is certainly a very important part of everyone's experience—or at least of almost everyone's. To remember anything is to reproduce past events in imagination. In perceiving the objects around us, as we shall see in more detail in a later chapter, we surround a sensation or group of sensations with a great number of images. Planning for the future would be impossible without imagination. The artist sees his finished work in imagination before he has even begun work on it. A business man looks ahead as far and as well as he is able, and makes his decisions on the basis of what he imagines the future will be. A successful general or war council must imagine situations that are likely to arise and plan appropriate measures to deal with them.

Individuals differ both in the clearness and vividness of their imagery and in the kinds of imagery upon which they principally rely. Some persons must see anything before they can understand it or remember it. For others it is enough to hear about it. Still others must go through various motions to get the feel of it in their muscles.

When such facts were first discovered, it was thought that they were immensely important for education. It

would be the first duty of teachers to classify the children in their classes into *visiles,* those relying on visual images, *audiles* who depend on hearing, and *motiles* who must get the feel. The visiles they would teach through their eyes, the audiles by spoken words, and the motiles through activity.

It was soon found, however, that most persons made use of all kinds of imagery. Individuals might prefer one or another kind, but few were really limited to any single one.

When I was in college, students commonly rode bicycles. We kept our bicycles in a room, the door of which was furnished with a combination lock. To work the combination it was necessary to turn the knob a certain number of clicks to the right, another number to the left, and another number again to the right. One morning I found to my dismay that I had forgotten the combination. Nevertheless I took hold of the knob. Though I was unable to remember the number, my hand (at least, that was how it seemed) had no difficulty. It went through the necessary movements. The door opened. I counted the clicks—which my hand seemed to know so much better than I did—and recovered the formula for the combination. When the professor of psychology a few days later lectured upon the types of imagery, I thought I had good

reason to believe I was a motile.

A course in elementary French in the same college provided excellent training in reading and writing the language but very little in conversation. Some years later I was thrown in with some French people. For a time I was unable to distinguish the words I heard around me. Talk was only a confused babble of sound. Then came a period when I could catch the words but was obliged to imagine what they looked like in print before I could grasp their meaning. Before very long the printed words dropped out and the sounds conveyed their meaning directly. So it seemed that I really preferred visual imagery and could adjust myself to the sound of words only with some difficulty.

But that was too simple a conclusion. I have had occasion to make some study of another language. In this case I mixed with the people, listened to what they said to me and to one another, and struggled as best I could to make myself understood. Each day I would ask my teacher what certain expressions I had heard meant and how I could say the things I wanted to. When it came to reading, my experience was the very reverse of that with French. The printed words carried very little meaning. I found I was obliged either to read the material aloud or to imagine as vividly as I was able how it would sound. Here I was

preferring auditory to visual imagery.

The conclusion seems reasonable that I make use of visual, auditory, and motor images with about equal facility. Which one of them it shall be in any particular case depends upon the specific habits built up.

Try asking your friends to find rhymes for such words as *lose* or *cost*. Eye-minded persons are likely to offer such words as nose, dose, noose, most, or post. You can call them visiles. Ear-minded persons, or audiles, will give better rhymes. Another interesting experiment is to ask a friend to spell some fairly long word backward. If he can see the word in his mind's eye it will be a simple matter to read off the letters. If his visual imagery is a little weak, the task will be difficult. Ask him how he does it.

Here is another experiment. Hold your mouth open and try to imagine such words as *bubble*, *mutter*, *wisp*. Of course you cannot *say* them without closing your mouth. Can you *imagine* them? Some people cannot. You may be able to find some such among your friends. Such people are probably strongly motor-minded—or motiles. If you can imagine the words (audiles find it easy enough to do so) do you feel at least a little twitching in your lips? I do.

You can have some fun with letter and number squares. Here are two. You can make up others to suit yourself.

k	m	t	q
c	b	r	w
z	l	d	h
f	x	g	j

2	6	4	3	0
5	9	7	1	8
0	8	3	9	5
4	1	6	2	7
9	4	0	5	3

Memorize a square by repeating the letters or numbers from left to right. When you have it well memorized, imagine that you see it on the wall or on a sheet of blank paper in front of you. Now read the columns from the top down or from the bottom up! Very few people indeed have strong enough visual imagery to do this.

Individuals differ perhaps even more in the vividness of their imagery than in the kinds they employ. We have already noted that some players of blindfold chess "see" the board and pieces clearly before them. Others insist they do not. Ask your friends how vividly or clearly they can imagine a room in their homes, or recall, let us say, the morning's breakfast. Probably you will find some who will say that they can do it very clearly, that all the mental pictures are bright and colorful. Others will say that they can, indeed, imagine the scene but the figures are vague and a dim gray. You may find a few who are positive that they do not have any imagery at all. They know that there are certain articles of furniture in the room, or that they had wheat cakes, bacon and coffee for breakfast—but they are positive they have no images.

Our images are limited in one very important respect. It is impossible for us to imagine anything absolutely new. We can combine fragments of old experiences in new ways. We can design new buildings, aeroplanes, or dresses; we may fit wings to a horse or fasten them to a boy's ankles; but always the elements are from our previous experience. Only the arrangement is new. If you doubt this, try to imagine that you have eyes that can see colors beyond the violet end of the spectrum. How do such colors look?

When we try to recall past experiences, our images are further limited, in most of us, to items to which we have given definite attention. That is one reason why testimony in court is so often inaccurate. The witness has rarely had any warning that something important was about to happen. He has not been instructed for what he should watch. So very often he fails to observe the crucial point. No determination to tell the truth, the whole truth, and nothing but the truth, no agonized going over the scene again and again, can recover the essential point that he just did not notice.

It is a common experiment in psychology classes to ask the students to image as clearly as they can the faces of their watches. When it is evident that all are doing so, the instructor asks two questions.

(1) Is the four written IV or IIII?

(2) Is the vertex of the V in VI pointed toward the center of the watch or toward the circumference?

When all have jotted down their answers, the instructor asks them to look at their watches. Nearly always in any large class, he can see a number of sheepish smiles. Some have written down IV, in spite of the fact that in their watches it is the Arabic numeral 4. Others have forgotten that the dial for the second hand fills the space that would be occupied by the VI.

Some children and a very few adults have memory images, however, that seem like photographs. Glance for a second or two at a common comb. Put it out of sight. Call up as vivid a mental picture of it as you can. Can you count the teeth? Some people can. Such people certainly have a great advantage over ordinary students when they have to recite or write examination papers. They can "see" the pages of their textbooks almost as clearly as if the books were right before their eyes! They need only to read from their mind pictures.

One law student turned in a long account of a case in the exact words of his text. Of course the examiners were sure he had been cheating. He explained that he had looked up the material just a little while before the examination and had simply reproduced it from memory.

This was more than the examiners could believe. They decided to test him. They allowed him to study a page of unfamiliar material for five minutes. When time was up he began to write. He reproduced about four hundred words perfectly. He did not make a single mistake even in punctuation.

Such extremely detailed and vivid mental pictures are called eidetic images. In some ways it seems a pity that they nearly always disappear as children grow up.

It is not clear just how we tell the difference between our images and the real objects around us. It is commonly believed that little children cannot do so with any great certainty and frequently confuse the two. Lonely children commonly invent imaginary companions and carry on long elaborate plays with them. If an unseeing adult sits down in a chair occupied by the imaginary companion, the child suffers acute distress. It seems that the images appear real to the child. On the other hand it may be only that the child is not aware of the importance of distinguishing between real things and happenings and those that are only imagined.

As we grow older, we learn that imaginary fires will not warm our houses or cook our food, and that we cannot pay our bills with imaginary money. We learn ways of distinguishing between what we really see, hear, or

touch and what we only imagine, even though we cannot tell just how we do so. In general the images seem to lack a certain force or liveliness that the real experiences possess. We can do things with our images, too, that we cannot do with real things. We can make them come or go, we can change their sizes, we can combine them as we please. Real things, on the other hand, we cannot control in any such easy fashion. Instead they control us to a large extent.

Some images we are all of us very likely to confuse with actual sensations. If the sensation is very faint, we frequently are unable to tell whether we are actually seeing or hearing something or only imagining it. In many psychological laboratories there is an instrument called an audiometer. This instrument gives tones of any desired pitch or loudness. One of the interesting problems we can study with its aid is that of the very faintest tone one can hear—at any particular pitch. The procedure is simple. The instrument can be made to give a very faint tone indeed—too faint for the ordinary ear to detect. The tone can be made louder and louder until it becomes painful. It is possible, of course, to start with the loud tone and diminish it until it is no longer audible. The listener signals when he first hears the tone (if it is increasing) or ceases to hear it (if it is growing fainter). Subjects in this

experiment make every possible mistake. They signal that they hear the sound when the instrument is really silent, and they frequently fail to notice it when it is distinctly louder than their real limit of hearing.

Singers and violin players sometimes make use of this confusion between real and imagined sensations. As the last note dies softly away, a singer may leave his mouth open a few seconds after he has ceased to make even the least sound. The violinist may continue to draw his bow after he has actually lifted it off the strings. The audience thrills with ecstasy at the marvelous diminuendo.

Sight can be fooled as easily as hearing—perhaps even more easily. In a dimly lighted room a lantern projects a picture of some simple object, say a banana, on to a screen. This can be in all degrees of brightness. The subject is instructed to imagine the picture of the object on the screen and to report when the picture really appears. Under such conditions it is difficult to distinguish the very faint real picture from the one that is only imagined. The subject will report that he sees the picture when there is none there, and that he is only imagining it some time after it is actually visible.

Our memories are subject to similar confusions. Details are both lost and added. Sometimes we honestly remember things that never happened. You may have heard

someone say, "I don't know whether I actually remember this or only think I do because I have been told about it so often." Interesting stories frequently grow with successive tellings—though we have no intention to embellish them.

Some individuals lose the ability to distinguish between imagination and reality. They see things that are not really present or hear sounds for which there is no real basis. Their imaginations may be either pleasant or unpleasant. The confusion may be the result of some drug, such as alcohol, or it may be a way of escaping from some unhappy situation or tormenting thoughts. If it is the result of a drug, it will pass away when the effect of the drug wears off. If it is permanent, we say the person is insane and make special provision for him. One woman in a hospital for the insane tended with the utmost devotion for some twenty years a large rag doll. She fed it, dressed and undressed it, bathed it, and put it to bed. It was her baby. Her real baby had been killed in a railway accident. A Negro cook in a railway diner found life hard and unsatisfying. One day he awoke to the fact that he was not a Negro cook but a beautiful white woman. He was also immensely wealthy. To crown all, he was both the father and the mother of all the children in the world! He has been happy ever since—in a state hospital.

It would be a mistake to conclude from such extreme cases that it is dangerous to indulge in imagination or that daydreams are likely to lead to insanity. Imagination may be either helpful or damaging. We have seen that imagination is absolutely essential for the business man, the soldier, or the artist. It is through imagination that we are able to bring distant things close and make them effective in the choices we have to make. Imagination can reach backward into the past and forward into the future. So it can bring before us here and now the things that have been and even those that have not yet been. It is through imagination that we can hold ourselves to steady work at disagreeable tasks for the sake of some far-off goal. Imagination may be fun, too, like play.

There is danger only when we allow imagination to take the place of real work with real things. It is easier to dream of winning races or ball games than to go through the grind of athletic training, to plan the spending of a million dollars than to hustle around and earn fifty cents, to enjoy social success among imaginary friends than to cultivate the traits that will win us real friends. Daydreams are helpful, if they give us fresh strength for our daily work. They are dangerous, if they become substitutes for real work. And they are most dangerous of all, if our liking for them leads us to believe they are real.

Answer:

The cubes are

Black on 3 sides	8
" " 2 "	12
" " 1 "	6
" " 0 "	1
	27

CHAPTER IX

PERCEPTION

NEARLY everyone enjoys a good exhibition of magic. It is fun to be completely fooled—so long as we are sure it will not cost us more than the price we are willing to pay. We thrill with astonishment and laugh at our own bewilderment as we see right before our eyes one happening after another that we know to be simply impossible.

Magic is more than fun to a psychologist or a philosopher. It is indisputable proof that we ought not to believe everything we see. There are many other proofs, too, that we frequently see things that are not so. It is just as true that we often fail to see things and happenings that are in plain sight or right under our noses.

That is because seeing—or rather perceiving—is not a purely passive process. It is not something that happens to us. The things and events around us do not write themselves, nor does any outside agency write them, on our minds, as we write words on sheets of paper or on blackboards. Perceiving is something we do. It is the response

we make to the stimuli that come to us over the wires of our senses. We can make mistakes in every kind of action; so, of course, we can make mistakes in perception.

Courtesy of Professor E. G. Boring

Look steadily at this picture of a pretty woman. Soon it will change to a picture of an ugly hag. What has changed? Certainly not the lines, the lights or the shadows on the page. Nor can it be the picture in the inside of the eye. The more you think about it, the clearer it will appear that what changes is the meaning you give to certain elements in the picture. The ear of the pretty woman a moment later becomes the eye of the hag. The lines

that form the pretty woman's chin and lower jaw serve just as well to outline the huge nose of the hag. The whole trick of drawing puzzle pictures is to arrange the various parts so that they can mean two (or more) different things.

Meaning is something we add to what our eyes give us. That is the difference between perception and sensation. Our eyes, our ears, the reporters in our skin, and all our other sense organs supply us only with the raw material for perception. Perception is the interpreting of sensation. It is realizing what the sensation means. Usually, of course, it is not a matter of a single sensation but of many of them.

Usually this interpreting is so quick, and it fuses so completely with the sensation, that it is difficult to separate the two. Very rarely, if ever, do we experience any sensation that we do not at once interpret in some way or other. But when our interpretations change, it is easy to understand that our eyes supply what we may call a core of sensation. This core we fit now into one set of meanings and again into another.

Perception is not only interpreting by adding or filling in; it is also a process of selecting and combining. Lift your eyes for a moment from this page and look at anything—a chair, a picture on the wall, a pencil on a table.

You can see it easily enough. In your field of vision, however, are many other objects. The object you perceive is only a part of a complex picture. As a matter of light waves, of physical and chemical processes in your eyes, its lines and surfaces, its lights and shadows, do not stand out in any very signal fashion. Yet you have somehow selected it from everything else in your field of vision for observation. All perception is a selecting of some items out of many more.

It is also a process of combination. As I am writing these lines, I see a vague pattern of yellowish white—my hand. Partly within this pattern and partly above and below it I see: (1) a gray cylinder that I identify as an eraser, (2) a strip of bright white metal, (3) a long yellow streak, (4) a whitish triangle or cone, (5) a small black triangle or cone in contact with the paper. That is a very long way of saying that I see, or perceive, a yellow pencil in my hand. Moreover I see it at once as a whole. I do not first see the separate parts, then consider various possibilities, and finally conclude that they must mean I am holding a pencil. I see the pencil. Indeed in a sense I saw the pencil before I saw the separate parts. It seems to be true generally that we see whole pencils, and other wholes, before we distinguish the parts.

There is a story that a famous teacher of biology used

to give new students each a single scale of a fish to study. The rash and careless students would report in a few minutes what they had found. The teacher would say only, "Go back and study it some more." Hours and even days of intense study were necessary before even the best of his students could see in the fish scale all that he believed they ought to see. This is an excellent example of the way in which perception develops by selecting definite elements from large, vague wholes, separating them into parts, and putting them together again in meaningful combinations.

Other senses than seeing yield perceptions, too, and the same principles apply to them. When we first hear people speaking a foreign language, it is a meaningless jumble of sounds. If we stay with such people long enough and listen carefully, still more if we really study the language, we begin to notice certain words. One by one, or sometimes in groups, words come to stand out from the total confusion. By the sense of touch women test wool, cotton, or silk. In a dark room most of us can pick out familiar articles such as pencils, handkerchiefs, neckties, shoes, and so on by touch alone. We do not need our eyes to tell us that we are eating bacon and eggs.

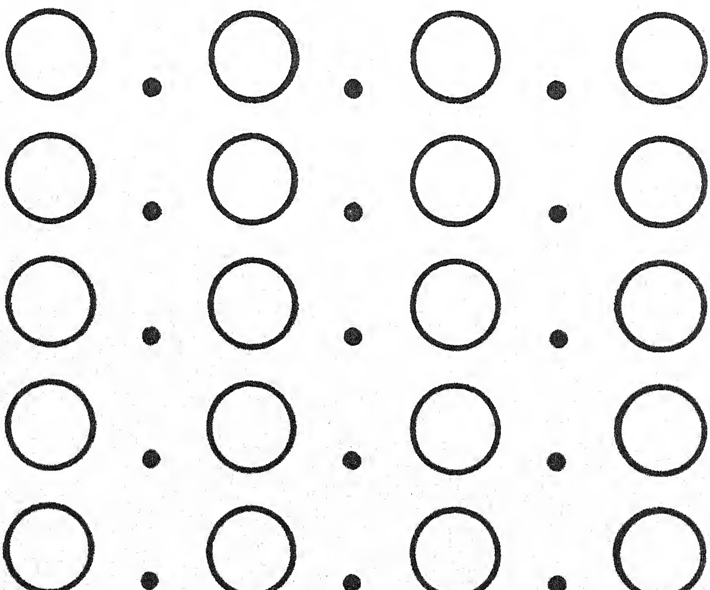
Like the factors that determine the direction of attention, those that influence perception lie partly in the ob-

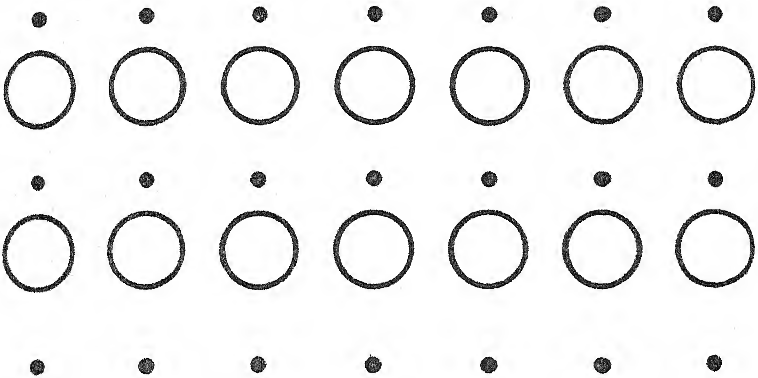
jects around us and partly in ourselves. How do you see the dots below?

1 2   3 4   5 6   7 8   9 10

Do you see them as 2-3, 4-5, 6-7, 8-9, with 1 and 10 left over? You can do so with a little effort and for a little while; but it is much more natural to see them as 1-2, 3-4, 5-6, 7-8, and 9-10. If instead of dots we were to use taps separated by times proportional to the distances between the dots, we should hear them in the same way.

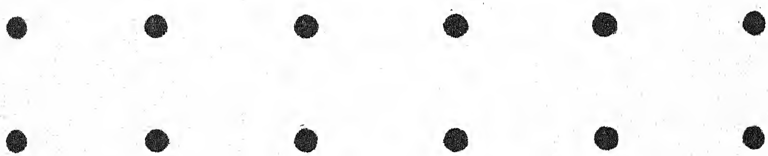
Look at these two figures—

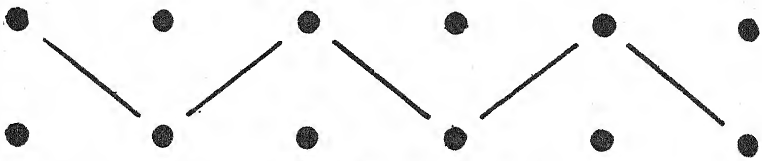




Do you see the one at the left as a group of horizontal lines made up of alternate circles and dots, or the one on the right as vertical lines made up in the same way? Again you can do so with some effort; but unless you do make the effort, the circles seem to group themselves together and the dots the same, to give us vertical lines in the figure at the left and horizontal lines in the one at the right.

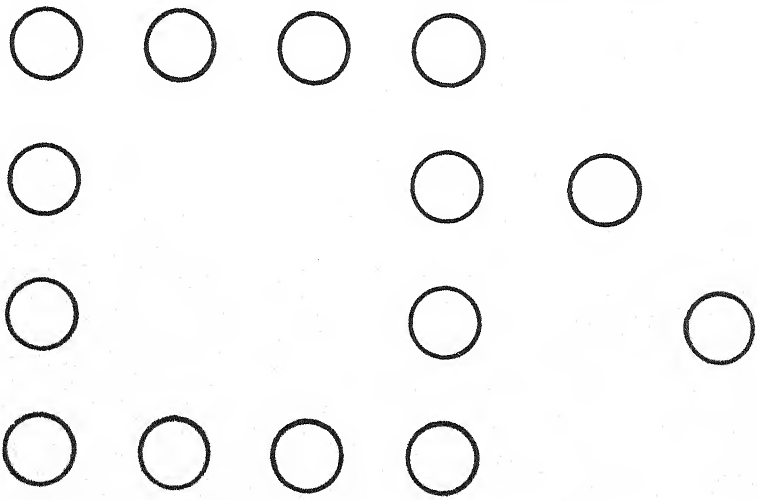
Here are two other figures—





Notice how the addition of a few lines changes the entire pattern.

In the figure below, the circles that form the square seem to belong together. The other two seem left over. You may even experience a slight feeling of annoyance at not being able to fit them into a single picture.



These figures illustrate four principles.

Credit is hereby acknowledged for the use of these diagrams to *Psychology* by J. J. B. Morgan, Farrar and Rinehart, Inc.

(1) *Nearness.* Items that are close together are more likely to be combined than those that are more widely separated.

(2) *Likeness.* Items of the same shape, color, or size are more likely to be seen as a group than those that are unlike.

(3) *Continuity.* Any hint that the items are connected in any way, in space, or time, or operation, tends to make them a unit for perception.

(4) *Inclusiveness, good pattern, or compactness.* Items that fit into an acceptable pattern are more likely to be seen as a group than others that cannot be so included.

A fifth factor that lies partly in the objects and partly in ourselves is that of familiarity. We have already noted how words come to stand out from the confusion of an unfamiliar language. A good conductor of an orchestra hears every instrument distinctly, the director of a choir each individual voice. Workers in noisy factories carry on conversation in their ordinary voices, separating the sounds of speech from the sounds that fairly deafen a newcomer. A botanist, an ornithologist, or an entomologist, we have already remarked, sees things in the course of a walk through a wood that an untrained person never notices.

Our past experience works principally by determin-

ing the attitude, the expectation, or the "set" with which we approach any object or situation. We are very likely to see the kind of things for which we are looking. Other things that may be just as important, and that would be just as striking if we were interested in them, remain wholly unnoticed. Charles Darwin and his friend Sidgwick took a trip into Wales looking for fossils. Absorbed in their search, they never noticed the signs of glacial action. On a later trip they saw them everywhere.

An amusing illustration of the way in which our expectations may determine what we see is provided by the story of some German music students in Paris who wished to express their appreciation of their teacher in a poem. The first line of the poem read

O singe fort
(O sing forth)

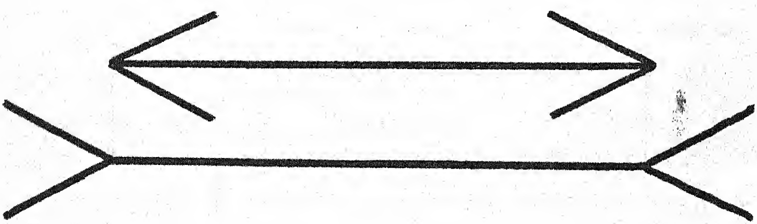
That was certainly a vigorous and rhythmical beginning. Unfortunately the teacher, being in Paris, was "set" to read French. In that language the line read, "O strong monkey!"

A trivial little experience of my own illustrates the way in which a strong expectation may lead us to see things otherwise than as they really are. In this case "seeing" happened to be tasting. At a church supper I helped

myself to what I thought was strawberry jam. The first bite of the stuff was entirely satisfactory. The second seemed a little strange. Not until the third or fourth mouthful did I realize that it was not strawberry jam, of which I am very fond, but fig jam, which I detest.

An interesting group of errors in perception is made up of certain well-known illusions. An illusion is a wrong interpretation of some real stimulus. If there is no external stimulus at all, if what one sees is wholly imaginary, we speak of it as an hallucination. A delusion, finally, is a mistaken belief. There are many illusions to which almost everyone is subject. One of the simplest of them is the Muller Lyer illusion. The two straight lines below are of equal length.

See what happens when we add a very few more lines.



Even if you take a pencil and draw faint vertical lines connecting the ends of the four horizontal lines, you can hardly see that they are all equal.

An interesting illusion of touch was recorded by the great Greek scientist and philosopher, Aristotle, about 330 B.C. Cross two fingers and rub a pencil between them. Soon you will feel two pencils. The reason for this illuson is easy enough to understand. Under ordinary conditions the pressure of a pencil on those two sides of your fingers would mean two pencils. Try it on your nose. Many persons report that they get the amusing impression that they have two nores!

Another very common illusion is known as the proofreader's illusion. That is a little unfair to professional proofreaders, since they take particuler pains to avoid it and develop a high degree of skill. Even they cannot completely escape it, however. In alnost every book there are a few misspelled words or other typographical errors in spite of the efforts of several professional readers. There are four misprints purposely left in the last two paragraphs. How many of them did you notice as you read?

Again the explanation is simple. Enough of the word is correct to set off the old, well-practiced response. We fill in the gaps in our observation with what we know ought to be there. We even go beyond mere filling in,

and see what we have reason to expect rather than what is actually there.

Some errors in perception are due to injuries to the brain. Some unfortunate persons are word-deaf or word-blind. The word-deaf can hear ordinary sounds as well as anyone, but spoken words, no matter how familiar they may have been at one time, carry no meaning. It is as though they were words of an unknown tongue. The word-blind can see objects as well as any other people. They can see written or printed words as black marks on white paper. They can even copy them, as we would copy a drawing. But the black marks do not mean words to them.

It is possible to become skillful in perceiving as in any other activity. Professional proofreaders make fewer mistakes than ordinary persons who try to do such work. Inspectors in factories soon learn to pick out faulty products quickly and surely. Experts in gems sort their precious stones and detect flaws or imitations with a certainty that comes only from long practice. Policemen make better witnesses than ordinary citizens, because they are trained and train themselves in observing. And so we might go on through a long list. Everyone acquires some skill in perceiving and dealing with the kinds of things with which he or she has most to do.

To be good observers we must cultivate the habit of alertness to as many signs or cues as possible. We should not form our judgments on the basis of just one or two striking or exciting features. We must be willing to change, when we have reason to believe our first impression is wrong. We must form the habit of looking at things in a number of ways, trying out now one view and now another. We must be careful, finally, to keep our emotions and our perceptions separate. This is very far from easy. We are all tempted to see things as we want them to be. Yet if we go through life on this principle, the result is sure to be disastrous.

CHAPTER X

THE PERCEPTION OF DISTANCE AND MOVEMENT

MOST of the objects around us have length, breadth, and thickness or depth. Moreover they are at varying distances from us. The world we see, in which we move around, and to which we have to adjust ourselves, is one with three dimensions, right—left, up—down, and near—far.

The ability to perceive depth or distance, the nearness or farness of objects, seems not to be instinctive. We are not born with it. It is a skill that we all have to acquire. The judgment of depth or distance is really a very complicated process, in which we make use of a great many experiences of many kinds. In ways we have learned are effective, we use them as signs to tell us how close or how far away are the objects at which we may be looking.

When once we have acquired a fair measure of skill, we make the necessary judgments so quickly and so easily that it is difficult to believe the process is really very complicated or that there was ever a time when we were un-

able to carry it out. It is easy enough to prove, however, that that is true. Think first of certain athletic sports—football, basketball, baseball, hockey, polo, boxing. In all of these you can see at once that contestants must develop a very quick and accurate judgment of distance. A matter of an inch in distance or of a fraction of a second in timing may make all the difference between brilliant success and dismal failure. The skill that successful athletes display is the result of long and often tiresome practice. Moreover constant practice is essential if it is to be maintained at its best. The ludicrous mistakes of beginners in such contests are due not only to the fact that they have not learned the proper movements but also to the other fact that they have not learned how to tie up the movements of their muscles with the cues that their eyes supply.

Little children make ridiculous mistakes in their judgments of distance. They often reach for objects that are far beyond the stretch of their little arms. Sometimes they overreach for objects that are close by. Even adults make ridiculous blunders when they find themselves in situations with which they are not familiar. A person who moves from the eastern states, where the atmosphere is frequently hazy, to the western plains, where the air is dry and clear, misjudges the distances of hills and other

natural objects in ways that provide amusement to those who have come to know the country well.

Still another bit of evidence comes from those rare individuals—so intensely interesting to psychologists—who have been born blind but in adult life have been given their sight by a successful operation. These persons have to learn to connect what they see with what they previously touched or handled. Such a person does not realize that what he sees as a strange shape is the chair in which he is accustomed to sit. He cannot tell by looking at it that a ball is round. Of course he makes absurd blunders in his judgment of distances—bumping against tables and chairs or walking ridiculously far around them. Here is an interesting account of some of the experiences of an eighteen-year-old girl who had been blind from birth and who suddenly gained her sight.

> When she first caught sight of her black-spotted dog, she was alarmed at what she took to be holes in the poor animal. Sunbeams baffled her, for even as she reached for them, they eluded her touch. She had walked for so long without the aid of her eyes that her mother had to teach her how to coordinate her steps with her visual cues. She found the process so difficult that when she wished to hurry she closed her eyes and felt her way about, in keeping with the habits of coordination thoroughly established over a period of years. "You can't tell a person how anything looks unless he has once had eyes that saw," she says. "The words don't mean a thing to him." *

* Wayland Vaughan, *General Psychology*, page 101. Copyright 1939. (The Odyssey Press, Inc.)

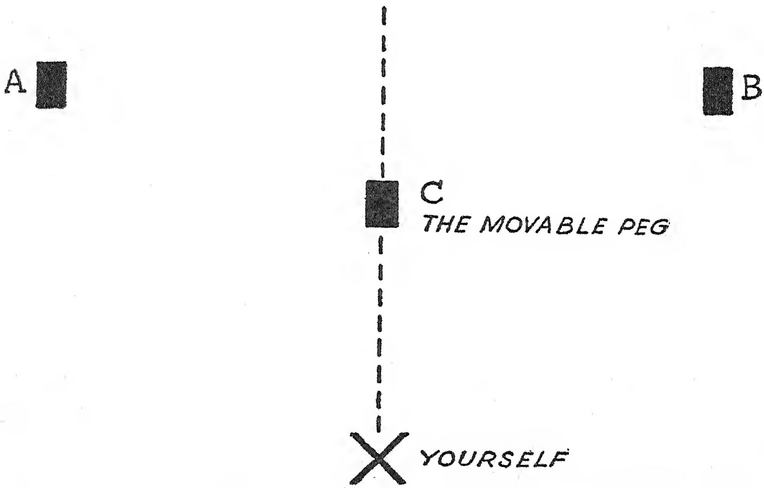
There are a couple of interesting experiments that you can very easily perform. For one of these you need no more apparatus than two pencils. Take a pencil in each hand. Hold each with the eraser down, as though you were going to write with that. Close one eye. Spread your arms wide. Now bring the two pencils together in front of you at about the level of your eyes until the erasers touch. Try it again, this time using both eyes. Note how much easier it is with two eyes than with one.

The explanation is that each eye sees something a little different from what the other sees. You can easily convince yourself that this is so, if you will close first one eye and then the other and compare what you see with each eye. We put the two pictures together without realizing that they are two. The difference in the two views helps us to judge the distance.

For another very simple experiment you need three pegs and someone to help you. Matches, toothpicks, large pins, or spools are good enough pegs. Fix two of the pegs upright on a table or board about a yard apart and at right angles to the direction from which you are going to look at them. Mark the mid point of the (imaginary) line between them. Now move back until you are about two yards from the line. (See illustration on page 125.)

Stoop or crouch until your eyes are about on a level with

the table or board. Now instruct your helper to move the third peg backward or forward in the direction shown by the dotted line until you think it is just on the line between A and B. Measure the mistake each time. Try it



several times using one eye, and as many times using both eyes. Again you will see that two eyes are much more accurate than one. That must be because we have learned to take the differences in the pictures given by the two eyes as a sign or measure of distance.

We shall have more to say about this later. It is only one of the signs of which we make use. All pictures are flat. Our eyes are very like cameras. They, too, give us

pictures. A picture is made up of lines and colors, lights and shadows, all arranged on a flat surface. In a picture nothing is in front of or behind anything else. How, then, do we get the impression of depth of distance.

Besides seeing pictures, we have all our lives been moving around, approaching objects and avoiding them, withdrawing from them, reaching for them, and moving them

around. We have seen human beings, houses, automobiles, and countless other things grow large in our field of vision as we came close to them, smaller as we went away from them. We have walked along railway tracks that seemed to come closer and closer together in the distance but proved to be the same distance apart at every point. We have noticed that when two hills look like this illustration, they are not side by side but one is in front of the other. So we have learned what apparent size, covering, perspective, clearness or haziness, and the play of lights and shadows mean as signs of distance. We tie these visual cues up with our kinesthetic experiences of moving about, reaching and handling. In that way they become signs and measures of distance.

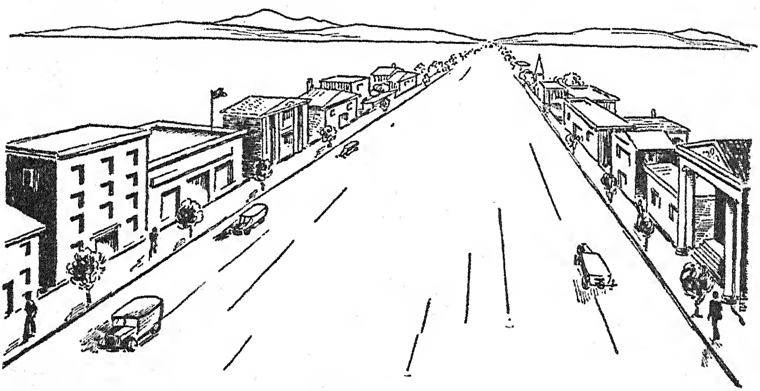
If—and that is a very big, impossible if—we had never had any experience of movement forward and back or around, it seems probable that we should never have any idea of a third dimension, depth or distance. Nothing would seem to come close to us or go away from us. We should simply see objects and persons growing larger or smaller. Nothing would seem to go behind anything else. Instead it would seem that the nearer object simply cut into the farther one.

Once we have learned the meanings, we use them so quickly and easily that it is difficult to believe the process is as complicated as it really is. It is something like learning a foreign language. For a long time we have to translate every word into our own speech. When we are really masters of the new tongue, that is no longer necessary. We think as easily and naturally in the new language as in our own. Then, of course, both languages are really our own.

It may help us to realize how complicated the process is, if we try to reverse it, that is, to draw a picture of a number of objects at different distances. Many people—I am one of them—find it very difficult to see things as an artist must see them, in the flat. To help me, an artist once suggested, "Imagine that you are looking at the scene through a glass window. Then you have only to trace on

the glass the lines and the patches of color you see." By long practice and study artists learn how to make use of the factors we have mentioned.

The common stereoscope neatly illustrates the way in which we make use of the different views provided by



our two eyes. Glass prisms cause us to see two pictures as though they were one. The pictures are not simply two prints from the same negative. They are taken from two different points of view, often with a double camera. In the double camera the two lenses are a little farther apart than human eyes. The two pictures are therefore different in certain small points. When the two pictures fuse into one, these differences give a surprisingly realistic depth. Objects stand out in very realistic fashion.

There are stereoscopic movies, too. Here again two pic-

tures are flashed simultaneously on the screen. The audience is provided with spectacles that produce the same effect as the prisms in the stereoscope. When one looks through them, the right eye sees one picture, the left another and slightly different one. If you try to watch the pictures without the glasses, they look badly blurred. But when you look through the spectacles at them, everything stands out clearly in three dimensions.

If the two pictures are taken from points a little farther apart than the normal distance between human eyes, the stereoscopic effect, that is, the depth, is exaggerated. Photographers sometimes do this deliberately to produce comic effects. By such a trick it is easy to make a person sitting in a chair look as though he has arms or legs grotesquely long.

If the pictures are taken too far apart, they will not fuse at all. And you will not see them both at the same time. You will see now one and now the other. This is the result of what we call retinal rivalry. The two pictures are so different that we cannot make them fuse. On the other hand we cannot split our attention between the two or attend to them both at the same time. So we attend to one until we lose interest or become a little tired, and then attend to the other.

Hold a piece of red glass in front of one eye and one

of blue glass in front of the other. You will see around you not a purple world, still less one world of blue and another of red. You will see a red world for a time, then a blue one, then a red one, and so on. If you want to carry the experiment a little further, keep a record of the number of seconds the view remains of one color. You will probably find that one eye dominates somewhat over the other. We are right- and left-eyed very much as we are right- and left-handed.

But let us come back to our stereoscope and the perception of depth. An exaggerated stereoscopic effect has an important practical value in aerial photography. If you have been up in an aeroplane, you may have been disappointed to see how flat the whole of the scene below you looked. It looks more like a map than a view. Suppose a photographer in a plane snaps two pictures in very rapid succession. At the very quickest, the plane will have traveled many feet between the two shots. When the two pictures are viewed through a stereoscope, it is as though we were looking at the ground through eyes 20, 50, or 100 feet apart. Now we no longer see a mere map. Every little elevation or depression stands out clearly. This is of great value in aerial surveys. In war time it makes effective camouflage extremely difficult.

The two last illustrations should serve to bring out once

more the fact that seeing is not something we do wholly with our eyes but is rather an interpretation or working over of the raw material—sensation—that our eyes provide. Here is still another illustration. Take a coin—a cent or a nickel. Hold it about a foot away from your eyes. Look at it again when you are holding it at arm's length. Place it on its edge and move away from it to a distance of three or four feet. At all these distances it looks the same size. Yet you know that the farther it is away from you, the smaller portion of your field of vision it fills. If you were drawing a picture, you would have to draw it smaller, the farther away you wanted it to seem.

Now make a pinhole through a piece of paper or cardboard. Look at the coin through the pinhole. Move the coin toward your eye and away from it. See how the apparent size of the coin shrinks as you move it away, and increases as you bring it closer. The reason is that when you look at it in any usual fashion, you see much more than the coin. These other factors provide cues for judging its distance. You know that it is a cent or a nickel so far away. So without being in the least aware of what you are doing, you correct what your eyes tell you and see it at its real size over a wide range of distances. The pinhole, on the other hand, narrows your view to very little more than the coin. The cues for distance are lack-

ing. So you do not have the chance to work over the raw material of sensation. You see a larger or a smaller disk of a certain color, and almost nothing but that. The disk fills a larger or a smaller part of your field of view.

For the second illustration—observe the full moon at your next opportunity when it is just coming up over the horizon and when it is overhead. How huge it looks on the horizon! It may be a surprise to learn that it does not really fill any larger area in your field of view at that time than when it is overhead. Yet that is easy enough to prove. Hold a coin in front of your eye at such a distance that it just covers the moon's disk. You will have to hold it as far away when the moon is on the horizon as when it is directly overhead. Another way is to measure the moon's disk with a ruler. You can regulate the distance of the ruler from your eye with a bit of string. Or look at the moon through opera or field glasses. Any way you try it, the results are the same.

The explanation is that the objects between you and the moon, when the moon is on the horizon, make it look farther away. Since it fills the same portion of your field of view at what seems to be a much greater distance, you refuse to accept the evidence of your eyes and see it as much larger.

The perception of movement, like the perception of distance, is much more complicated than it seems. A moving object casts a continuously moving image of itself on the retina of the eye. It seems as though that should be stimulus enough. That is too simple an account of the matter, however. If you move a picture before your eyes, and are careful not to follow it with your eyes, you will probably see only a blur. The portion of our eyes that is sensitive to light, the retina, does not respond instantaneously, nor does it cease responding the very instant a stimulus is removed. In both cases there is a lag of a few hundredths of a second. The lag is so short that we do not notice it, but it has important consequences.

Suppose that one tiny area in the retina responds to an image of an object in motion. Before it has time to respond fully or accurately, it is stimulated by something else, and again by something else, and so on. Plainly the result can be only a blur. Usually we follow a moving object at least a little distance by turning our eyes in the direction of the motion. This keeps its image on the same place in the retina. We see the changes in its relationships to the other objects around it. In that way we see it moving. If an object is moving fast enough, the image of it moves so quickly across the retina of the eye that no part

has time to respond to it. No one can see a rifle or revolver bullet as it is shot out of the muzzle of the weapon. (If you are in exactly the right position behind a large cannon, you may be able to see the shell.) You cannot see the spokes in the wheel of a bicycle, if the wheel is turning at a moderate speed.

On the other hand, we often seem to see movement when there really is no movement at all. Moving pictures, as we all know, are a succession of still pictures. The separate pictures, moreover, do not move across the screen. The strip of film does not unroll smoothly. It does so by rapid jerks. A film is exposed, and projected on the screen, for a fraction of a second. Then a shutter cuts off the light. In the brief period of darkness the next film is moved into position. The shutter opens. The light again projects a picture on the screen, and the process is repeated. When the rate at which the pictures appear on the screen is 16 or 24 per second, we no longer notice the periods of darkness. We fill in the gaps both in space and time between the pictures with what can be only our imagination.

The fundamental principle of moving pictures was discovered as long ago as 1833. Part of the effect is due to the lag in the activity of our eyes of which we have

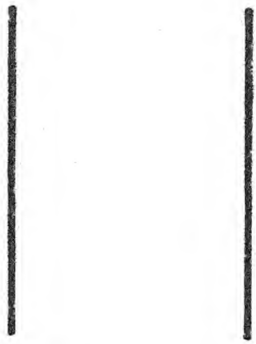
already spoken. The periods of darkness between the pictures are so short that our eyes do not have time to let go the pictures they are forming for us. This explains well enough how we come to fill in the times between the pictures. It does not explain, though, how we fill in the spaces between the successive positions of the objects in the pictures. Yet it is plain that we do. We do not see an object now in one position and the next instant in another. We see it moving across or through all the space between. This must be the result of imagination governed by habits that are the result of much experience of moving about and of dealing with moving objects.

A very great amount of study has been given to this problem of apparent movement. It would take us much too long to tell about them even briefly, but here are two experiments you can try for yourself.

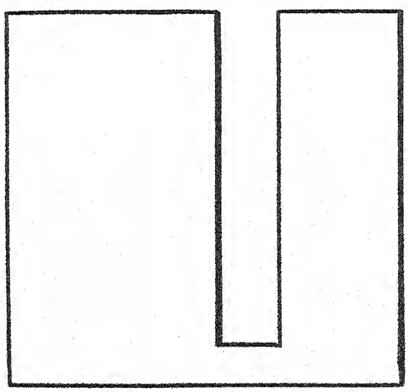
(1) Hold a finger or a pencil upright three or four inches in front of your nose. Look at it first with one eye, then with the other. If you open and shut your two eyes alternately and fairly rapidly, you will see the finger or pencil move from one position to the other.

(2) Draw two parallel vertical lines. Cut a small slit in a card. (See illustrations on page 136.) Move the card from side to side across the vertical lines so that you can see

first one and then the other, but never the two at the same time. If you do it slowly, you will see only one line and

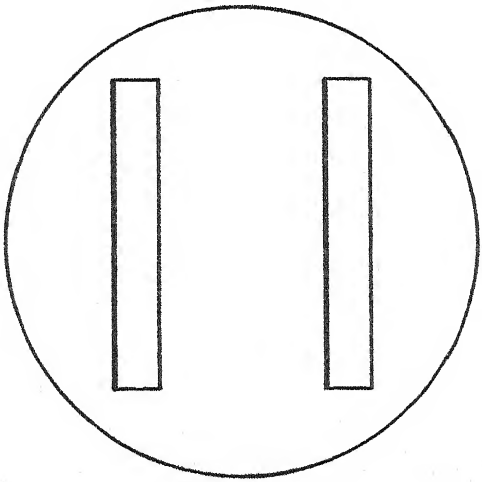


then the other. If you do it fast enough, you will see them both. But at just the right speed, in between, you will see



the line moving across or through the intervening space from one position to the other.

You can improve on this, if you want to cut two windows in a circular disk opposite each other, so that one will fit over each of the lines when the disk is rotated. Spin the disk around a pin and watch the lines move. (See illustration.)



CHAPTER XI

FEELING AND EMOTION

If you bite into an apple, you will experience various tastes, smells, and pressures. If it is a good one, you will also experience pleasure. If it is bad—in any of the many ways in which apples can be bad—your experience will be unpleasant. This matter of liking or not liking what our senses report is a kind of experience we have not yet studied. It is a very large and important part of everyone's experience but it is peculiarly difficult and puzzling.

In the first place, the English language does not furnish us with just the words we need. It has no word for the opposite of pleasure. Pleasant and unpleasant are good, clear opposites; but we do not speak of unpleasure. Displeasure suggests anger and disapproval rather than merely the opposite of pleasure. Pain, though it is commonly used, will not do—at least in psychology—for pain is a sensation—an ache, a burn, or a sting. And a small amount of pain, we have already observed, is not unpleas-

ant. Perhaps the best we can do is to speak of pleasure and unpleasantness or dislike.

Pleasure and unpleasantness seem to slip out of every attempt to analyze or describe them. They are so elusive that psychologists are by no means agreed as to what they are. It is common to speak of them as feelings, but that is only a name. It does not explain anything. Psychologists cannot agree as to what feelings are or how many feelings we ought to list. This should serve as one more reminder that psychology is a very young science and has only begun its gigantic task of explaining behavior and experience.

The pleasure we feel in eating a good apple is something more than the sight, the taste, or the smell of it. Something more—but what? It is tempting to say that it is another sensation or group of sensations. We shall see a little later that this may be true; but here are some reasons to doubt it.

What is the sense organ for pleasure? Our eyes give us vision, our ears hearing, but what sense organ (or organs) yields pleasure? Pleasure, moreover, acts very unlike a sensation when we attempt to study it. The more you attend to and examine the taste of an apple, the clearer it becomes and the more you can discover in it. But try to examine the pleasure! It slips right away from you.

Very different sensations may be either pleasant or unpleasant. What can be more different as a mass of sensations than vigorous exercise and rest. Yet each is pleasant at the proper time.

One possibility is that pleasure is an attitude of readiness to accept, continue, or intensify the sensations one may be experiencing or expecting to experience. Unpleasantness, then, would be the readiness to refuse, push away, avoid, reject, or diminish. It may be that kinesthetic sensations, the feel of our muscles that are almost—but not quite—doing these things is a very large part of pleasure or dislike.

The fact that our attitudes toward sensations frequently change seems to me to fit in well with this way of looking at the matter. There may have been a time when you did not like olives—and now you may be very fond of them. You may even be able to remember just when this change, or some other change like it, took place. What changed? It seems certain that it was not the taste. It may have been the attitude, the set of the muscles, from a readiness to spit the olives out and make other avoiding movements to a readiness to roll them around under the tongue and make the taste as strong as possible.

Severe pain is nearly always unpleasant. Slight pains, we have already noted, however, are frequently pleasant.

Even severe pain may become a matter of indifference; it may even be actually enjoyed, if it fits into some dominating purpose. Football players, prize fighters, and workers in rough trades learn to disregard pains that would render less hardy individuals helpless. The explanation may be that they do not experience the sensations much less keenly than ordinary persons but that they have learned not to fight against them or try to escape them. In the slang of our day, they have learned to "take them."

It would be an interesting experiment to see whether you can deliberately and intentionally change your dislike for something into liking for it by changing your attitude from one of rejecting to one of accepting. If you try it, write to me and tell me how successful you were.

There may be other feelings than pleasure and dislike. The feeling of familiarity or strangeness is very difficult to analyze into anything simpler. So are the feelings of sameness and difference, or expectancy and surprise, and of amusement. The whole subject of the feelings is one of the most confusing and least understood in the field of psychology.

Very much like feelings but vastly more complex are the emotions. Anger, fear, love, grief, are just a few of the many words in our language used to name them. Here

is a description of some of the results of fear. It is a little long, but it is so detailed and interesting that I think you will want to read it all.

> Fear is often preceded by astonishment, and is so far akin to it that both lead to the senses of sight and hearing being instantly aroused. In both cases the eyes and mouth are widely opened and the eyebrows raised. The frightened man at first stands like a statue, motionless and breathless, or crouches down as if instinctively to escape observation. The heart beats quickly and violently, so that it palpitates or knocks against the ribs. . . . The skin instantly becomes pale . . . due to the contraction of the small arteries. . . . Perspiration immediately exudes from it. This exudation is all the more remarkable, as the surface is then cold, and hence the term, a cold sweat. . . . The breathing is hurried. The salivary glands act imperfectly; the mouth becomes dry and is often opened and shut. I have also noticed that under slight fear there is a strong tendency to yawn. One of the best marked symptoms is the trembling of all the muscles of the body; and this is often first seen in the lips. From this cause, and from the dryness of the mouth, the voice becomes husky or indistinct or may altogether fail. . . . As fear increases into the agony of terror, we behold, as under all violent emotions, diversified results. The heart beats wildly or must fail to act and faintness ensue; there is a deathlike pallor; the breathing is labored; the wings of the nostrils are widely dilated; there is a gasping and convulsive motion of the lips, a tremor on the hollow cheek, a gulping and catching of the throat; the uncovered and protruding eyeballs are fixed on the object of terror; or they may roll restlessly from side to side. . . . The pupils are said to be enormously dilated. All the muscles of the body may become rigid or may be thrown into convulsive movements. The hands are alternately clenched and opened, often with a twitching movement. The arms may be protruded as if to avert some dreadful

danger, or may be thrown wildly over the head. . . . In other cases there is a sudden and uncontrollable tendency to headlong flight; and so strong is this that the boldest soldiers may be seized with a sudden panic.*

Here is a shorter description of hate:

Withdrawal of the head backwards, withdrawal of the trunk; projection forwards of the hands, as if to defend one's self against the hated object; contraction or closure of the eyes; elevation of the upper lip and closure of the nose,—these are all elementary movements of turning away. Next threatening movements, as: intense frowning; eyes wide open; display of teeth; grinding teeth and contracting jaws; opened mouth with tongue advanced; clenched fists; threatening action of arms; stamping with the feet; deep inspirations—panting; growling and various cries; automatic repetition of one word or syllable; sudden weakness and trembling of voice, spitting. Finally, various miscellaneous reactions . . . : general trembling; convulsions of lips and facial muscles, of limbs and of trunk; acts of violence to one's self, as biting fist or nails; sardonic laughter; bright redness of face; sudden pallor of face; extreme dilation of nostrils; standing up of hair on head." †

If you have read these descriptions of two emotions, you will certainly agree that emotion is a disturbance of the whole body. We might say that *e*motion is an extensive bodily *com*motion. The disturbance involves muscles, vital organs, and glands. Indeed it is difficult to think of any part of the body that is not affected.

* Darwin, *Origin of the Emotions*, pp. 290-292. Quoted in James, *Psychology*, pp. 446-447. 1890. (Henry Holt and Company.)

† James, *Psychology*, p. 447. 1890. (Henry Holt and Company.)

In strong emotional excitement many bodily changes take place. Here are a few of them:

The digestive operations are suspended throughout the entire digestive tract. The stomach ceases its contractions. The salivary secretion ceases. The mouth and throat become dry. The heart beats faster and more energetically and the blood pressure increases. The skin may either grow pale or redden. The reddening is due to the larger supply of blood, the paling to the constriction of the blood vessels in the skin. The constriction of the blood vessels tends to force the blood away from the surface of the body into the muscles. Breathing becomes deeper and more rapid. Tiny muscles in the skin cause the hairs to stand more or less erect. You have probably noticed this in the tails of cats when they are frightened or angry. Human beings show a similar reaction to *very* strong excitement, though it is rarely so visible. We do speak, though, of being so frightened that one's hair stands on end. The same muscles may cause the sweat glands to stand out. This causes goose pimples. The pupils of the eyes are dilated. Chemical tests show that the liver is secreting large amounts of sugar into the blood. Sugar is the great source of energy for the muscles. The adrenal glands, next to the kidneys, secrete an extra amount of adrenalin into the blood. This reinforces all the processes we have listed

above. In addition it diminishes fatigue in the muscles and helps the blood to form clots, if there are wounds.

All these changes are believed to be due to the increased activity of what we know as the sympathetic nervous system. The structure and the functions of this great system of nerves deserve a whole chapter, or even a whole book, to themselves. Any good book on physiology will give you an account of them.

In addition to these organic reactions under the control of the sympathetic nervous system there are innumerable muscular activities that we commonly call the expressions of emotion. A number of these we have already noticed in the description of hate. The organic conditions are very much the same throughout a wide range of emotions. The muscular movements and sets, on the other hand, are very varied. There is the activity of flight or the preparation for it. This, of course, goes with fear. Anger involves the attitude or the actual movements of attack. And so we could go on through a long list of emotions. Probably we shall not be far wrong if we think of emotion as a general excitement involving almost the entire body. Whether it is fear, anger, disgust, or some other particular emotion depends upon what we may call one's attitude toward the stimulus that causes the disturbance.

You have surely read or heard about a poker face. That

means that the individual of whom one is speaking is very successful in suppressing all facial expression of emotion. The Japanese people seem to us inscrutable, because their faces do not register emotions with the same liveliness as do the faces of our friends and acquaintances.

Detectives, diplomats, and others whose work demands a quick and accurate judgment of character or intentions develop a high degree of skill in interpreting very minute signs indeed—slight movements of eyelids, a little twitching of the lips, a momentary change in breathing, the smallest movements of the hands, feet, or fingers. When a master of interpretation meets a master of concealment, it is a battle royal.

Even a master of concealment would find it very difficult, probably impossible, to suppress all the organic disturbances. The lie-detector, of which you must have read, is an assemblage of instruments which register organic disturbances. When the instruments have all been attached and everything is in readiness, the investigator asks the witness a number of questions. Some of them can be easily and safely answered. Others are very important. A guilty person, or one who is attempting to conceal anything, experiences some disturbance. He may be able to control his voice and his facial expression, but the blood pressure, the psychogalvanic reflex, or some other indicator

betrays him. Even a very slight disturbance, such as one might expect to be involved in lying about one's age, shows up clearly.

An innocent person, knowing that he was suspected of crime, or at least of lying, might also be excited or worried by some of the questions. It would not be at the same questions, however, as those that would disturb the guilty or dishonest one. When it is operated by experts, the lie-detector gives a very dependable result.

The fact that the organic states are the same over a wide range of emotions makes it fairly easy to tell that a person is experiencing *some* emotion, but it is almost impossible, if he is clever at concealing it, to tell just which emotion it is. Individuals differ, too, in the ways in which they react to emotional stimuli. Finally, there are a number of emotions, among them some of the commonest and best known, that do not show the organic reactions we have described. We do not know just what organic states go with curiosity, amusement, grief, or joy.

There are three other words having to do with emotion with which we ought to become acquainted—moods, temperament, and sentiments. A mood is a readiness for a certain kind of emotion rather than the fully developed emotion itself. While emotional excitement lasts only a short while, moods may persist for hours or even

days. Emotions are usually roused by particular objects or situations. A mood is more general and less definite. It is a readiness to become emotional at almost anything. When we are irritable or touchy, almost anything will make us angry. When we are jolly, almost everything seems amusing. For most persons moods vary according to the situations they meet or their physical condition. In some individuals, however, some one mood seems to prevail nearly all the time. Such an enduring mood we call temperament or disposition.

Hippocrates (about 400 B.C.) taught that there were four temperaments. Each had its basis in one of the fluids of the body. The *sanguine* (hopeful, enthusiastic) man was so because of richness of his blood. The *phlegmatic* (slow, dull) man was burdened by an excess of phlegm. Too much bile (choler) made an individual *choleric* or excitable and irritable. Too much black bile or spleen produced *melancholy.* (Melas is the Greek word for black.)

This was putting it much too simply; but the old Greek physician may have been on the track of something very important. It is entirely possible that substances in the blood may have a very great influence upon our behavior. Alcohol in the blood certainly changes many persons' temperament for the time being. The presence or

absence of certain vitamins in the diet may make all the difference between vigorous high spirits and laziness, irritability or gloom. Certain glands in the body, too, such as the thyroid, the pituitary, the adrenal, and the sex glands seem to have much to do with our behavior as well as with our physical development.

A sentiment is a cluster of tendencies to certain actions and emotions around an object, a person, a group, or it may be an idea. Patriotism is a sentiment and a very powerful one. It is the readiness to do certain things in situations that involve our country's welfare or honor, and to experience pride, joy, sorrow, anger, or other emotions appropriate to the situations that develop. Love is usually much more than a single emotion. Love for a particular person is a readiness to do many different things and to experience many emotions. We may say that religion is a sentiment, a cluster of tendencies to action and to emotion together with beliefs around the idea of God.

What would life be without feeling or emotion? Try to imagine what it would be like to know things and happenings around you as well as you do now, or even better, but to care nothing at all about anything. Nothing would please you. Nothing would trouble you. Nothing would frighten you or make you angry. Nothing would be good and nothing evil. You might see things as clearly

as a good mirror reflects the objects in front of it; but you would be as indifferent to it all as a mirror is.

It is plain that feeling and emotion give us all of what we call the values of life—the joys, the sorrows, the loves, the hates, the satisfactions and the disappointments. It must also be plain that our feelings and emotions are very closely connected with our endeavors. If we were without emotion or feeling, if we cared for nothing, we would undertake nothing. We would make no exertion or effort.

On the other hand, suppose that we were only emotion and activity. Suppose that we had no knowledge or reason. Then we could have no plans. We could act only upon the impulse of the moment. In running about in such violent and aimless fashion, we should bump into all kinds of obstacles and into one another. We should be like cars rushing about without drivers.

We shall have more to say about reason in another chapter. Just now it is enough to say that reason is the ability *not* to act only from the impulse of the moment. It is the ability to hold up action until we have looked around and ahead. It is the ability to govern our actions by the long view rather than for the immediate thrill.

Everyone likes high power in a car. Emotion is power in our lives. But the higher the power, the more we need intelligence at the steering wheel.

CHAPTER XII

REFLEXES

ONE OF the astonishing things about very young babies is the strength with which their little hands will grasp a finger, a rod, or a pencil, or anything that is put into them and is not too large. Some new-born babies hold so tightly that they can be lifted clear of support and will hang for a number of minutes before letting go. The strength of grip in the little fingers seems out of all proportion to the strength of other muscles. This reflex tends to disappear at the age of about 120 days.

If you are on friendly terms with a good-natured dog, see if you can demonstrate the "scratch reflex." Persuade the dog to lie on its side. Pat its head, talk to it, and otherwise occupy its attention, while you scratch lightly at several points on its side.

You will see the hind leg on that side make pronounced, fairly vigorous scratching movements. There is something a little strange about the movements. They do not make up a complete scratch. The dog's foot probably will not

actually reach his side at all. Moreover, the animal does not seem to be doing it intentionally. It seems to be a purposeless, merely mechanical movement.

You can produce in yourself, or in some friend, a reflex that is something like that. Sit on the edge of a table or some other support that will allow your lower leg to swing freely. Locate the patellar tendon. That is the large tendon that runs below the kneecap. When the knee is bent so that the upper and lower parts of the leg are at right angles, the tendon is stretched. Tap the tendon lightly with the side of your hand or with anything that will serve as a light, padded hammer.

Your leg will jerk, with a kicking motion. It is entirely an involuntary act. You may find it rather an odd feeling. Your leg seems to act of itself, without asking your permission or consulting you in any way. If you try to prevent it, you only make the kick more pronounced. It seems to happen as independently of any intention of yours as the doorbell in your home rings when someone presses the button.

In our study of behavior it seems wise to begin with the very simplest kinds. It is generally agreed that these are the reflexes. In this chapter we shall see what happens in a reflex and of what importance reflexes are.

When the hammer strikes the patellar tendon, it stim-

ulates an end organ receptor of a nerve. The nervous impulse travels along the nerve until it reaches the spinal cord. There it connects with an out-going nerve. This nerve carries the impulse to the muscle in the thigh, and the leg jerks or kicks. The receptor, the in-going nerve, the central connection, the out-going nerve, and the effector (in this case, the muscle) are said to make up a reflex arc.

That is the very simplest thing that could happen. Only very rarely, if ever, is any reflex quite so simple. The nerve of which we have been speaking is made up of many fibers. Some of these fibers connect with others in the spinal cord that carry an impulse up to the brain. Unless they did that, it must be plain that we would not feel the blow of the hammer.

A finger may be stimulated at the same time. In that case another group of impulses reaches the brain. Some impulses may run downward as well as upward and connect with those from the patellar tendon to the nerves that stimulate the thigh muscle. So the motor nerves and so the muscle will be doubly stimulated. Impulses may come also from eyes and ears. In the brain the possible connections are so many that we cannot begin to count them. As a result of them all, an impulse or group of im-

pulses travels downward from the brain. The final response, therefore, may thus be the result not of a single stimulus but of many stimuli from many sources and connected in many complicated ways with many parts of our bodies.

It is practically certain that there are no simple reflex arcs. We cannot think of a reflex as a complete, enclosed, self-contained little machine, something like the sealed-in motor of an electric refrigerator. We shall have to say that some actions are performed almost as though they were due to simple reflex arcs but that they may be modified by many influences.

For different individuals, and depending also to some extent upon the methods of the experimenter, the time of the knee jerk varies from .01 to .09 second. The extent of the movement varies according to the stimulus, for different individuals, and for the same individual at different times and under different conditions. Both are affected by the tensing of muscles either in the leg itself or in other parts of the body, by added stimuli such as lights or sounds, by emotional excitement or lethargy, by drugs and by still other factors.

Experimenters sometimes cut the spinal cord of a cat or a dog so that no impulses from the brain can go

through. Human beings sometimes suffer a similar injury. The effect is to speed up the reaction of the reflex. In the cat the reaction time may be as short as .006 second! This shows that the brain acts as a check or delay upon the more mechanical operations of the nervous system. Our brains, we may say, make it possible to stop, look, and listen instead of responding in a merely mechanical fashion. Stopping, looking, and listening provide an opportunity to consider, and to act upon, other stimuli than the one that is most obvious and immediate.

There have been many attempts to list and classify reflexes. Here is an interesting one that groups them under five heads according to the degree in which they are subject to voluntary control. We cannot regard the list as in any way complete, but it will serve to give some idea of the extent to which our lives and our behavior are matters of simple, definite, inherited nervous connections that operate in a nearly mechanical fashion.

Table of Reflexes *

A. *Pure, Seldom Modified in Adult*

Pupillary or iris reflex
Ear twitching (controlled in some individuals)
Withdrawing hand (to heat and pain)
Digestive reflexes
Shuddering
Starting (to sudden noises, etc.)
Shivering
Trembling

* See page 156 for footnote.

B. *Inhibited or Reinforced in Adult*

Winking	Twitching hand (to pain)
Accommodation of the eye	Vasomotor changes (blushing, paling)
Eye-fixation and convergence	Changes in breathing
Hiccoughing	Sweating
Sneezing	Groaning
Knee jerk	Laughing
Yawning	Squirming
Vomiting	Tickle reflexes
Facial expressions	
Salivation	

C. *Often Modified in Adult*

Coughing	Smiling
Swallowing and gulping	Wincing, etc.
Reflexes to odors	Scowling
Gasping	Stretching
Weeping, sobbing	Convulsive contractions

D. *Always Modified in Adults*

Sucking	Tugging (wrist reflexes)
Biting and grinding	Clasping (elbow reflexes)
Spitting	Reaching (shoulder reflexes)
Hunger and thirst reflexes	Kicking (knee reflexes)
Lip and tongue reflexes	Stepping (gluteal reflexes)
Vocal reflexes	Jumping (ankle reflexes)
Turning the head	Sitting up
Tossing with the hand	Bending forward
Grasping (finger reflexes)	Rising

E. *Posture Reflexes*

Holding head erect	Standing
Sitting	Maintaining balance

* Warren, H. C., and Carmichael, Leonard, *Elements of Human Psychology*, pp. 395, 396. 1930. (Houghton Mifflin Company.) With a few omissions and minor alterations.

Certainly it is fortunate that so much of our life and behavior is a matter of reflexes. Think what life would be like if you had to give definite attention to all the activities that our bodies must carry on! The wisest and ablest man would find his own body far too complicated a machine for him to run successfully. How could little babies do it?

Instead of that we find the most necessary activities running themselves, almost mechanically, needing only a very little thought or direction. Our bodies are wonderful self-regulating machines. At the same time they are not so mechanical that we are limited to just a few ways of acting. Even the "purest" reflexes are subject to some control. All can be modified in many ways.

Once more we may compare every living human being to a large business. The manager of such a business, we have already observed, cannot afford to give his time and thought to its innumerable details. To deal with them he has his assistants, his foremen, and his workers. And the workers operate machines. One secret of good organization is to make as much as possible of the necessary work mechanical. Machines can take care of a large part of it. For work that is only a little more complicated there are the workers. As one moves up the ladder of rank in the

organization, the work becomes less and less mechanical and demands more and more of intelligence, flexibility, initiative, imagination, and leadership. In our own organization we may think of our reflexes as the workers at the bottom of the scale, humble folk, attracting little attention, busy with humdrum tasks that must be done over and over again.

CHAPTER XIII

INSTINCTS

It certainly is fortunate for us that we did not have to learn to breathe, to suck, to swallow, to digest, and in general to do all the innumerable things that must be done if we are to go on living. These activities, we have seen, are governed by a very large number of relatively simple, ready-made connections between receptors, nerve centers, and effectors. These simple connections we have learned to call reflex arcs, and the actions that result from stimulation of the receptors we call reflexes.

We have compared our bodies to large business organizations with many grades of workers, foremen, and managers. It is not a wild flight of fancy to say that our bodies are already going concerns when we take over the management of them at birth. Every one of us, like a new manager of a business, can discover the possibilities of his or her body and establish control of it only gradually. It is an interesting question, and one of great practical importance, to what extent the business is already organized

before we take over control, to what extent, that is, our behavior is determined by inherited structures more complex and more flexible than simple reflexes.

There is some evidence that the organization has proceeded very far indeed. This shows up more clearly in animals than in human beings. In ourselves the original organization, whatever it may be, is very quickly and very deeply covered over with new ways of doing things. In the lower animals the original organization—or what seems to be that—stands out more clearly. For an example read this account by Wheeler of the behavior of the solitary wasp.

The female Sphex, after mating, digs in sandy soil a slanting or perpendicular tunnel and widens its end to form an elliptical chamber. She may thereupon close the entrance, rise into the air and fly in undulating spirals over the burrow, thus making what is called a "flight of orientation," or "locality study," because it enables her to fix . . . the precise position of the burrow in relation to the surrounding objects, so that she may find the spot again. Then she flies off in search of her prey, which is a particular species of hairless caterpillar. When it is found, she stings it into insensibility, malaxates its neck, while imbibing the exuding juices, and drags it or flies with it to the entrance of her burrow. Here she drops her victim and, after entering and inspecting the burrow, returns and takes it down into the chamber, glues her egg to its surface and closes the burrow by filling it with sand or detritus collected from the surrounding soil. As soon as the next egg matures in her ovaries she proceeds to repeat the same behavior cycle at some other spot. In the meantime the provisioned egg hatches, and the larva, after devour-

ing the helpless caterpillar, spins a cocoon, pupates *in situ* and eventually emerges as a perfect Sphex.

Some of our species of Sphex actually tamp down the filling of their burrows with a small, carefully selected pebble, held in the mandibles and used as a hammer or pestle.*

It is plain that the wasp has had no opportunity to learn this very complicated behavior. It must also be plain that her movements are much more than simple mechanical reflexes. They are adapted to the situations that arise. No two situations can ever be exactly the same.

It seems that we have to reckon with an original, inborn organization of sense organs, nerves, and muscles, very limited in its functions, and yet astonishingly flexible and varied. If we may go back to our illustration of the large business, it is not like the simple duties of the unskilled or even the skilled laborers but rather the work of a manager of a department, whose duties are carefully defined but who is allowed a large measure of discretion in carrying them out.

Such a complex, flexible, original, innate or inherited organization is commonly called an instinct. It is a more complex affair than a reflex, though it is probably impossible to draw a sharp line between the most complicated reflexes and the simplest instinct. Like the reflexes, how-

* Wheeler, W. M., *Social Life among the Insects*, pp. 53-55. 1923. (Harcourt, Brace and Company.)

ever, instincts are made up of inherited structure, of connections between receptors, nerve centers, and effectors.

The principal questions with regard to instincts are: Do we really inherit such complicated patterns of behavior? If there are instincts, how shall we recognize them? If there are instincts—what are they? To what extent do instincts—and again we must add, if there are any—determine human behavior?

Until about 1920, instincts were very much in fashion. One student of the literature, Bernard, reported that he found more than five thousand patterns of behavior described as instinctive! There were a number of psychologists, however, who objected to this way of explaining human behavior, or even that of animals. Bernard's book, published in 1924, was a devastating attack upon the belief in instincts. Since that time the opponents of instincts seem to have been having much the better of a hot argument.

There are three main objections to explaining behavior by reference to instincts. The first is that behavior seems to be much more variable than it could be if it were due to instincts. Careful experiments have shown that many forms of behavior that were supposed to be instinctive were really learned. One of the most interesting of these studies is that by the Chinese psychologist Kuo as to the

tendency of kittens to catch and kill mice.

To most people it probably seems that cats inherit an instinct to catch and kill mice and rats. Kuo reared three groups of kittens under three different conditions. Twenty kittens lived each in its own cage, with no chance to see or smell a rat or mouse. Twenty-one lived in cages with their mothers and saw them kill a rat or mouse outside the cage every four days. Eighteen kittens lived each in a cage which it shared with either a large white rat, a medium-sized wild rat, or a small dancing mouse.

The tests consisted in introducing a large white rat into each kitten's cage. If the large rat was not killed within 30 minutes, it was removed and a medium-sized wild rat was put in. If the wild rat was not killed in 30 minutes, the small dancing mouse was substituted. If that was not killed within the time limit, the test was called off. The tests began when the kittens were six to eight days old and were continued every four days until each kitten had either killed one of each kind of rodent or had reached the age of four months.

Of the twenty kittens that had never seen their mothers kill rats or mice, only 9 killed any of the three kinds of rodents. Of the 21 that had seen their mothers kill, 18 killed sooner or later. Of the 18 that had lived with the rodents, only 3 ever killed at all—and these 3 never killed

the kind of animal with which they had lived!

We shall have to agree with Kuo that whether cats kill mice and rats or not depends very largely upon the experience they have had. What can we say, then, of the instinct? This is only one of many studies that show how variable supposedly instinctive behavior is, even in animals.

On the other hand, we must in fairness acknowledge that there are careful studies which show the sudden appearance of fully developed and very complex behavior patterns that there has certainly been no opportunity to learn.

The second objection is that an instinct should be regarded rather as a problem for study than an explanation. Read over again the account of the way in which the solitary wasp lays her eggs. It certainly looks like a very convincing description of behavior that must be purely instinctive. But begin at the other end of the life story. Think of the egg sealed up in the body of the caterpillar, of the larva in darkness, with nothing but caterpillar meat to eat, and struggling little by little to freedom. Can we be sure that the environment and the early experiences may not have more to do with later behavior than the nervous connections that the creature inherits? Suppose that we could hatch some eggs in very different surroundings and feed the larvae on a different diet. Would that

change the wasps' behavior? No one has yet performed the experiment; but until someone does, we shall have to hold the questions open and suspend judgment. It is at least possible that we can explain the instinct in terms of some very much simpler factors.

The third objection is that attributing a bit of behavior to an instinct is not an explanation of the behavior at all but amounts only to naming it over again. In an old French comedy the hero asks a doctor of medicine why opium puts people to sleep. The learned scientist answers with great solemnity, "Because it has dormitive powers." To say that men fight because they inherit an instinct of pugnacity or accumulate fortunes because they have a strong acquisitive instinct seems to be just as futile and absurd an explanation.

If we try to balance all the arguments on both sides of this question, we must conclude that human behavior is not a matter of *either* inherited organization *or* experience or learning. We shall have to say that it is more or less the result of heredity and more or less the result of experience. Certain ways of acting seem to develop with developing muscles, glands, and nerves and with no need for learning. These ways of acting can be changed. The greater the change from what seems natural and normal, however, the more difficult it is to make. Probably there

are limits beyond which changes would mean either loss of life or lasting misery. It follows that we ought to approach any type of behavior not with the question, Is this instinctive or learned? but with the different question, To what extent or in what particulars is it the result of inherited organization or of exercise and experience?

There is really only one test by which to determine whether a bit of behavior is instinctive or not. That is the possibility that it has been learned. If we can be sure that it cannot possibly have been learned, we are justified in calling it instinctive. If there is the least chance that it may have been learned, or even modified by the experiences that the animal has undergone, we must suspend judgment and work patiently to disentangle the two factors of inherited organization and the influence of the environment.

How can we be sure, though, that a particular way of behaving has not been learned, or at least has not been modified by experience? One important bit of evidence would be the time at which the behavior pattern appears. If it is observed at birth or very shortly afterward, it is plain that there has been no opportunity to learn it. The later it appears, the greater is the likelihood that either the whole pattern or essential parts of it have been learned. Another bit of evidence is the degree of universality of

the pattern. If every human being, if every individual of a species of animals, acts in a particular way, we have good ground for suspecting that it is instinctive. It is unlikely that *all* individuals would learn the same way of acting. This is especially true, if the species is scattered over a wide area that includes many different kinds of environment.

Both of these tests must be used, however, with great caution. The fact that a behavior pattern does not appear until fairly late in life does not prove that it must have been learned. Permanent teeth usually do not begin to appear until a child is seven or eight years old. Wisdom teeth usually are not fully developed until the age of twenty, or even somewhat older. Yet certainly no one *learns* to grow them. The time of their appearance and some of their characteristics will be affected by diet, general health, and other results of one's environment and experience, but they are certainly inherited. In the same way certain ways of acting may depend upon the growth and maturing of connections between nerves that are as definitely inherited as teeth, or the color of eyes and hair.

The test of universality is also difficult to apply with absolute certainty. There are sure to be exceptions to every rule you can lay down. Some individuals will be found who do not show the supposed instinct. That may

not be a very serious objection—so long as there are not too many exceptions. More serious is the fact that many ways of acting develop among large numbers of people simply because of some common need or convenience. Great numbers of men and women keep accounts in banks and pay their bills by checks. No one supposes, however, that there is a bank-depositing or check-writing instinct. The practice of smoking is exceedingly widespread over almost the entire world; but we can be sure that it is learned and not instinctive.

One of the weak points in the arguments of those who do believe in instincts is that there has been no general agreement among them as to the number of instincts with which we ought to reckon. Some have wanted to reduce the number to two—the instinct of self-preservation and that of reproduction (the preservation of the species). This is not generally accepted by psychologists today. We find it very difficult to believe that either is true instinct. It does not seem probable that cats and dogs feel any impulse to produce kittens or puppies. *We* know that certain ways of behaving have that result, but the animals almost certainly do not. And when a cat runs away from a pursuing dog or climbs a tree, we doubt very much that it is trying to save its life. *We* see that running or climbing will have that result; but for the cat it seems probable

that the impulse is something far more specific and simple than that. The dog is a horrid object from which it must run away. Only a few of us eat our meals in order to preserve our lives or our health. Most of us eat because at certain times in the day we crave food and experience a lively pleasure in eating. Indeed we lose much of the real zest or joy of eating if we stop to think about the reasons for doing it. The effect of well-balanced, nourishing meals is to preserve life and health and to supply us with energy, but the drive we feel when we are hungry is not any of these things. It is simply to eat the food we have found appetizing.

Other believers in instincts have claimed that there are many more than two. Professor McDougal stated that in attempting to understand human behavior or experience we ought to reckon with at least eight definite instincts: flight, repulsion, curiosity, pugnacity, self-abasement or submission, self-assertion, the parental instinct, and instinctive sympathy.

Animals, we seem to be compelled to admit, must inherit some remarkably complex yet very definite tendencies to behave in particular ways in the situations they are likely to encounter. In describing human nature, however, psychologists today are more inclined to emphasize the almost limitless variability and what seems to be the

absence of any definite determining tendencies. Psychologists are strongly of the opinion that such inherited organization as there may be is of the relatively simple kind that we ought to call reflexes rather than instincts.

The absence of instincts would handicap the human race hopelessly in the struggle for existence, if the loss were not more than made good by intelligence. An instinct is an inherited tendency to act in a particular situation in a very definite way. Animals do not have to think what to do in the situations that they ordinarily have to face. There is something almost mechanical in the ways they act. Instinct is quicker and often more energetic than thought-out action can be, and often more effective. All this is very fortunate for the animals. When they are compelled to think, they do not do it very well. Yet the very completeness and perfection of instinctive action has its disadvantages. When conditions are changed, when situations arise to which a creature's instincts are not adapted, it is helpless. It may even leap to its own destruction. Hunters and trappers take advantage of the instincts of animals to kill or capture them.

Intelligence, unlike instinct, is not a tendency to do anything in particular. It is the ability to see the meanings of facts, to figure out the consequences of action, to take many things into account that are not at once obvi-

ous, and to do the *best* thing possible in any situation. If behavior were completely mechanical, there would be no chance for intelligence to operate. Beings that are to live intelligently must not be limited to narrowly particular ways of acting by too well-developed organization.

If human nature is a bundle of instincts, they are so quickly and so deeply covered with habits that it is very difficult to identify them. Take for an example the alleged instinct of pugnacity. The stimulus that at first will arouse it, we may assume, is some obstruction or injury. The original response is a wild, all-over, diffuse activity that may be very ineffective. In time the individual learns to fight more effectively, perhaps with modern weapons. His actual behavior now is very different from what it was at first. Words, too, may start him fighting even more violently than physical injury.

The question of instincts becomes of great practical importance when we are compelled to choose between conflicting standards of morals or between social institutions. Is it better for a man to have one wife or many? Would it be better to do business according to Communist plans or in the fashion that we call free private initiative? Those who cling to the old, accepted ways will always argue that you cannot change human nature; there will always be wars because an instinct of pugnacity is a large

part of human nature; there must always be private property because we are all born with an acquisitive instinct. In general, they say, things ought to be left as they are because the present arrangements fit human nature better than any others that may be under discussion.

Those who wish to change our ways of doing things argue that what the conservatives call human nature or instinct is no more than a group of habits. Human nature, they contend, is plastic and changeable beyond any limits that can easily be seen. Men actually do live happily and well under very different systems of morals and of institutions. They can learn to live under still others.

CHAPTER XIV

HEREDITY AND ENVIRONMENT

WHICH leg is more important for walking?

Which is more necessary for life—lungs or air? These are foolish questions, but they are not very much more foolish than the question whether heredity or environment is the more important.

Suppose that Isaac Newton's parents had somehow lost him when he was a baby, and that he had been found by Esquimaux and brought up in Greenland. It seems certain that he would never have made the wonderful discoveries that cause us to rate him today as the greatest scientist our race has yet produced. He might have invented an improved harpoon, designed a more seaworthy kayak, or built a better igloo.

On the other hand, hundreds, perhaps thousands, of men grew up and spent their days in environments very like Newton's. Yet only Isaac Newton developed the law of gravitation, the principles of mechanics, the calculus, and the other contributions to science that made him

unique among the great scientists. We shall have to conclude that we cannot think of achievement as due either to heredity or to environment alone. We shall have to think of it rather as a product of the two factors, as 6 is the product of 2 and 3. The finest environment the world can provide cannot make a great scholar or a competent business man out of an idiot, though exceptional opportunities have sometimes enabled men of modest abilities to accomplish creditable work. Again and again great men have accomplished wonders with most meager materials, but even the greatest men are obliged to make use of the ideas and the help of lesser men, and could accomplish nothing without them.

If we are to work successfully with both heredity and environment, we must know what each contributes to the development of the individual. The difficulty in the way of this necessary study is that we can never disentangle or separate the two factors. We can never lay our hands on pure heredity unmodified by environment. We can have no better success in isolating the factor of the environment.

It might seem that in the new-born baby we can find inherited structures and tendencies that the environment has not had time to modify. There are two reasons, however, why this cannot be true. The first is that even the

new-born baby is the product of its heredity and the environment in which for nine months it has been growing.

Within the body of the mother the developing child is astonishingly well insulated from outside influences. Its nervous system is all its own, with no connection with the mother's. Even its circulation has no direct connection with the mother's blood stream. Its entire body is cushioned in water against jars and shocks.

Yet even such insulation cannot be complete. The health or sickness of the mother affects the composition of her blood. Chemicals carried in her blood enter into the circulation of the developing child and affect its health. It is believed that some forms of idiocy are due to deficiencies in the mother's diet. Disease germs, too, may make their way through the surrounding membranes. There may be accidents and injuries during the birth process.

It was widely believed at one time, and perhaps still is, that the mother's experiences while the child is growing within her body strongly influence the character of the child. Thus some mothers have engaged in strenuous study, hoping to benefit the intelligence of the child or to equip it with a love for poetry, for mathematics, or some other subject. Others have made it a point to listen

to good music in the hope that the child would be musical.

What we know of pre-natal development makes all this seem utterly impossible. How could such extremely complex influences pass over from the mother to the child. There is no connection between their nervous systems. Even the blood vessels of mother and child do not join directly. They lie side by side and chemicals are interchanged through the walls by a process that we call osmosis. An emotional shock to the mother will affect her child, because it changes the activity of her glands and so the chemistry of her blood. Any chemical change in the mother's blood will affect the child—for better or worse. But we cannot see how a liking for mathematics or poetic genius can be dissolved in blood and produce a similar liking or genius in the child.

Along with a belief in pre-natal influences—except of a chemical or mechanical sort—we must reject the belief that one generation inherits what an earlier generation has learned. There are many reasons why we would like to believe this; but long and careful experiment has so far failed to establish a single instance in which any trait or way of behaving learned or acquired by one generation has been definitely inherited, in whole or even in part, by the next.

What looks like the inheritance of an acquired charac-

teristic is sometimes brought about in this fashion—the trait enables its possessors to survive, while those who do not possess it are killed off. The next generation is bred from animals that had shown the ability to acquire that trait. The next generation would be bred in the same fashion. So in time we would have a lot of individuals selected for their ability to learn a particular way of behaving. But remember that it is the ability which is inherited, not the trait itself.

We must get back, though, to our new-born baby and the second reason why we cannot take it as a representative of pure heredity. The second reason is that many structures and traits we know are hereditary do not show up at this time. As we saw in the last chapter, the growth and maturing of the body bring out many structures and ways of behaving that nothing we can observe in the baby even suggests.

In our discussion of instincts we saw there was reason to believe that whatever we inherit must be of some very simple sort rather than any complicated or very definite kind of behavior. It is certain that no one inherits a knowledge of mathematics. It may be, however, that children inherit more or less of a rather general ability that we may call intelligence. If very intelligent children become deeply interested in mathematics, they will prob-

ably make a success of that study.

As for musical ability, it may be that what is inherited is an especially sensitive ear, a peculiar structure of the hands or of the vocal organs, connections between nerves and muscles that make it comparatively easy to learn the movements a musician must execute, and particularly vigorous emotions. If all these factors are organized around music, the child may become a musician. The same factors, in other circumstances, might be organized about some other center of interest. The rich emotional equipment might find expression in poetry. The capable fingers might develop skill in surgery. It is not the knowledge of music that is inherited, then, nor even the love for it, but a certain bodily structure that makes it comparatively easy to acquire musical knowledge and skill. Whether that ability shall be directed toward music or some other undertaking may be decided entirely by the forces in the environment in which a child grows up.

Notice that all through these last paragraphs we have been saying "may be." Can we be sure? How can we be sure? The only honest answer is that we cannot.

One way to study the question would be to trace the history of many families. That has been done. It is clear that superiority and inferiority, both physical and mental, do run in families. The Edwards family in our own coun-

try has produced an astonishing number of distinguished men and women. The Jukes family has produced perhaps an even more astonishing number of criminals, paupers, feeble-minded, insane, and generally degenerate persons.

We cannot be certain, however, whether the results were due to heredity or environment. Perhaps the Jukes children turned out for the most part bad because they had to live with other members of the Jukes family, rather than because they were born of Jukes parents. Perhaps children adopted into some of the divisions of the Edwards family did as well as those that were born of Edwards parents. The only conclusive test would be to interchange babies, giving Jukes babies to Edwards families, and Edwards babies to Jukes families! It would be very interesting to know whether the babies would show the characters of their parents or of the families in which they were brought up. But an experiment like that, of course, is out of the question.

In nearly every scientific experiment the investigator varies some one factor, leaving all the others unchanged. If we could find a number of individuals all with the same heredity, we could explain their differences as due to the differing environments. If the heredity was of many kinds, we could attribute similarities to similarities in the environments. If we could place a number of in-

dividuals in the same environment, we could attribute the differences to heredity. Similarities appearing in very different environments we could attribute to similar heredity.

It may seem as though that ought to be easy enough to do. Actually it is all but impossible to find either the same heredity in any two individuals or the same environment. The only two persons with exactly the same heredity are identical twins. The same family is *not* the same environment for any two children. If they are boy and girl, one has a brother, the other a sister. Unless they are twins, one is older and the other younger. These facts alone make it impossible for a home to be the same for any two children—unless, perhaps, for identical twins.

When we study physical and mental measurements and school records, we find that children of the same parents resemble one another much more closely in all particulars than they do other children taken at random. While there are many exceptions, brothers and sisters do on the whole tend to look alike, to act alike, to make similar records in their studies, in athletics, in business, and in life generally. Twins are more alike than brothers and sisters who are not twins. Identical twins are the most similar of all.

Particularly interesting is the study of identical twins who have been separated in early life and brought up in

different surroundings. It has not been possible to find very many of these. So far only about twenty pairs have been closely studied. The results of the study have not presented any very clear pictures. Such evidence as is available seems to indicate that identical twins brought up in very different surroundings showed marked differences in personality, intelligence, achievement, and health.

Studies have also been made of the intelligence of adopted children. The results show that children placed in superior homes do show improvement in the scores they make on intelligence tests. On the other hand, those same scores seem to correspond more closely with the scores made by their physical parents than with those of the men and women who adopted them.

It seems reasonable to conclude that intelligence as a capacity or ability to learn is principally a matter of heredity. A child of modest abilities in a fine home, however, will learn many right and desirable ways of acting that a child of better abilities in an inferior home will never acquire. So he is likely to make better scores on tests, a better record in school, and prove generally more successful.

There are exceptions, of course, and in both directions. Abraham Lincoln grew to greatness in very inferior surroundings. Many children in the finest homes have fallen

far short of what it seemed reasonable to expect of them. Again we must bear in mind that achievement, personality, and character are the product of at least two factors. Perhaps it may help if we think of heredity as supplying our capacities, environment the filling. A bottle may have a capacity, say, of a quart. With what it shall be filled, and whether it shall be filled completely or only in part, depends upon the use we wish to make of it.

CHAPTER XV

INTELLIGENCE

THE STORY of how men learned to measure intelligence is a beautiful illustration of the way in which one scientific discovery leads to another and of how different nations work together for the common purpose of advancing knowledge.

From Germany came the idea that mental processes could be measured. For a long time thoughtful men had argued that there could never be a science of psychology, because the facts it would be obliged to study could never be measured. How long was an idea? How wide? How thick? How much did an idea of a thousand tons weigh? These were plainly very silly questions. But unless you could measure experiences, how could you build up a science?

In 1879 Wilhelm Wundt established in the University of Leipzig the first laboratory to form a part of a regular teaching program in psychology. William James in America had got together a few pieces of apparatus and with

some friends had made a few experiments; but it was not a part of any definite course of instruction. To Wundt's laboratory flocked enthusiastic young students from all parts of the world. From it they returned to found psychological laboratories in their own countries and to teach the new science that seemed to promise such wonderful and valuable discoveries.

At first the things that were measured were for the most part reaction times, thresholds (the least or the most intense stimuli to which we can respond), and discriminations (the ability to tell the difference between two stimuli that are very nearly the same). All that seems a very long way from measuring intelligence; but it accomplished two things that were extremely important. First of all, it convinced thinking men that things which had seemed out of the reach of scientific methods could be measured and that a science of psychology was really possible. In the second place students of the new science learned how experiments must be carried on.

In 1885 Ebbinghaus published the results of his studies of memory. We shall have more to say about these remarkable investigations in a later chapter. The point just now is that they proved that even one of the higher mental processes, as high a process as memory, could be measured. In 1897 Ebbinghaus published a set of tests for

school children. These included tests of memory, of arithmetical ability, and of intelligence!

The intelligence test was a simple fable, perhaps half a page long. From this story Ebbinghaus left out certain words and phrases. Children who took the test were told to fill in as many of the missing words as they could in the time allowed. At the beginning of the story the words left out were very easy to guess, like "the" or "and." Farther along in the story more words were left out, and they were harder to guess. This kind of a test, the completion test, is still widely used.

In France there was a lively interest in feeble-minded children and in the insane. Ever since the beginning of the 19th century, France had taken the lead in studying and caring for such unfortunate individuals. The stories of great French students of mental defect and disorder are among the most fascinating in the whole history of science. So is the story of the life of Dorothea Dix, who did so much to bring the work of these French pioneer scientists to America.

England contributed a very keen interest in the ways in which individuals differ from one another in every trait. Francis Galton set up a laboratory in London in which he and his assistants measured thousands of men, women, and children with respect to almost every char-

acteristic of which they could think. Galton and his students also developed complicated mathematical processes for tabulating and analyzing the measures they obtained.

America's contribution was a very convincing and very valuable demonstration of what psychologists ought *not* to look for if they wished to find a measure of intelligence. Studies made by Americans showed that no physical measurements were of the least value as signs of intelligence. Tall men were bright, average, or dull. So were short men. Men with small heads were the same; and so were men with large heads.

Now we must turn back to France. In 1904 the school authorities of Paris asked the leading psychologist of France, Alfred Binet, why children made such uneven progress in the schools and if any way could be found to tell in advance and quickly which children would profit by the ordinary types of instruction and which ought to be put into special schools.

Binet succeeded in devising the first tests of intelligence that proved generally workable because of two very original ideas. First, he gave up the search for any *simple* test. Earlier investigators had tried to find out how fast a person could think by noting how rapidly he could tap with his fingers. They had thought they might be able to measure judgment by finding out how accurately he could

judge the length of lines or discriminate small differences in weight. Binet chose instead common every-day problems such as all the children would be practically certain to encounter outside of school. He selected a number of such problems, of as great a variety as possible. These he arranged in order of their difficulty. The "1905 Scale" included thirty such tests. Children began with the easiest and kept at work until they could do no more. That gave at least a rough indication of the level of a child's ability.

If Jean passed twelve of his tests and Yvonne only nine of hers, it was reasonable to expect that Jean would be able to do more advanced work in school than Yvonne. But did that mean that he was brighter? Suppose Jean was sixteen years old and Yvonne only seven.

Binet's second idea was even more original and brilliant than the first. It was the idea of *mental age*. It would not be difficult to ascertain what tests average children of each age could pass. The scale could then be broken up into groups of tests for each age level. If a child solved the problems that the average child of ten would solve, we could say that mentally he was as well developed as the average ten-year-old. Another way of saying that would be to say that he had a mental age of ten years. If he was only eight years old, that would be a very superior performance. If, on the other hand, the child was sixteen or

older, he would be very much below the average. This made it possible to tell with some accuracy whether a child was below, equal to, or above the average. If he was advanced or retarded, one could say by just how much he differed from the average.

In 1916 Terman at Stanford University in California published a revised edition of the tests. He had many advantages that Binet had never enjoyed. He had, of course, the benefit of all of Binet's work. He was able to hire a small group of very able and highly trained assistants. He was better acquainted with the mathematical methods of dealing with test scores. Finally, he and his assistants had about a thousand children with whom to work.

Even more important than the revision of the tests was Terman's use of a new term suggested by Stern of the University of Hamburg—the intelligence quotient, ordinarily abbreviated to IQ. The word "quotient" means that there has been a division. If we divide the mental age by the chronological age the quotient will be a very useful indicator of how bright or dull a child is.

If a child of eight shows a mental age of 10, the IQ is 10/8 or 1.25. It is customary to omit the decimal point. This bright child is therefore said to have an intelligence quotient of 125. If a child of 15 showed a mental age of only 10, the intelligence quotient would be a little less

than 67. An IQ of just 100 would mean that the mental age equals the chronological age. That would mean that the child is exactly average.

Terman found reason to believe that growth in intelligence reached its limit at about the age of 16. In using the tests for adults, therefore, we take 16 as the limit for the divisor, no matter what a person's real age may be.

To administer a Binet test an examiner must sit down alone with one child for about an hour of very close, careful work. It would take a very large number of psychologists and a very long time indeed to test all the children and adults that ought to be tested. Plainly we need tests that can be given to large numbers of individuals at once and can be administered in a fairly short time.

In the first World War the United States Army felt the need of a test to select soldiers who could be sent to officers' training schools. Psychologists supplied tests that soon became famous as the "Army Alpha." Nearly two million men were tested. It was the first large-scale testing and is still probably the most extensive that was ever carried out. The tests proved very helpful indeed for the purpose for which they were devised. After the war they were widely used by schools and colleges, by employers, and by vocational advisers. They are still in use, though there are now many other tests better adapted to the particular

needs of schools or the various branches of industry.

Group tests are practically all of the pencil and paper type. A candidate is given several pages of questions and problems. He answers and solves as many as possible in the time allowed. Often there are easy ways of answering, such as drawing a line under one of several answers suggested, or drawing a circle around the number that is the correct answer.

Some persons, however, cannot read or speak English—at least not with ease and fluency. A Binet or an "Army Alpha" test would be very unfair to such individuals. For them psychologists have devised what are known as *performance tests*. The "Army Beta" test was one of the first of these. It was used for soldiers who could not read English. In a performance test the person to be examined is set a number of tasks to perform, beginning with very simple ones and going on to some that tax the ability of very intelligent persons indeed. Only the briefest and simplest instructions are needed. The materials presented make it plain what must be done. All the tasks have been standardized in essentially the same way as those on the Binet tests. Here are two examples.

In the first, which is called the Knox Cube Test, the examiner arranges four small black cubes in a line on a table:

1 2 3 4

The examiner takes a fifth cube in his hand and says, "Do what I do." Then he taps the cubes at the rate of one each second. When he has finished, he sets the cube he has been using in front of the person being tested and makes signs that he is to repeat the process.

The first series is very easy, simply 1, 2, 3, 4. The next goes 1, 2, 3, 4, 3. The next, 1, 2, 3, 4, 2. The next, 1, 3, 2, 4. You would have no difficulty at all with any of those. But you might find it difficult to remember such a series as 1, 3, 4, 2, 4, 1.

The second test is given on the Seguin Form Board. This is a board out of which have been cut ten geometrical figures: a star, a diamond, a circle, a cross, a lozenge, a crescent, a square, a triangle, an ellipse, and a rectangle. The examiner arranges the blocks in three piles beside the board and tells the child to put them back as quickly as possible. A number of trials are allowed. The best trial—the one that took the shortest time—is the one that is counted. I have never been able to put the blocks back in less than eleven seconds, but I have watched one of my students do it in nine seconds or perhaps eight. A young child, a very dull older child, or a feeble-minded adult will waste many precious seconds trying to fit the square into the place for the triangle or the circle into the place for the star, or something else just as absurd. In general,

the more intelligent individuals perform the task in shorter times, as they make fewer waste movements.

Not all tests yield a mental age and an IQ. Many give only a score. We can compare any individual's score with those made by others who took the test and see whether the individual in whom we are interested was above or below the average and by how much. Often that is all we want to know. Most of the psychological tests used by colleges to select their entering students are of this kind.

It is important to keep in mind the difference between intelligence and knowledge or information, or even ability. Perhaps the best way is to think of the difference between capacity and filling or content. A gallon jar has a capacity of four quarts. It may be filled with any of a large number of substances. It may be filled completely or only in part. Intelligence is capacity. It is not information but the ability to acquire information. It is not skill but the ability to become skillful. An office boy may be more intelligent than the president of the company for which he works. That does not mean that the two ought to trade jobs. The president has filled his capacity with a vast amount of valuable material which only years of practical experience can provide. He may be less intelligent but at present he is certainly more able and more valuable to the company than the office boy. Twenty

years from now the office boy may be a much better president, but just now he is only a young man with a future.

A high intelligence is no guarantee, however, of success either in school, in work, or in life generally. Keen intelligence is like a sharp tool. One does need it to do really superior work in any field; but if it is misdirected, it will do only harm. Achievement—superior achievement—we have already remarked, is a product of several factors. Besides intelligence there must be effort (hard work). There must also be opportunity. There must again be those traits, mostly emotional, that we group vaguely under the term personality. Our very intelligent office boy, if he is to become a great president, or even a mediocre vice president, must be able to work with other men and to get them to work loyally and happily with him. For that he needs tact and certain moral and emotional qualities.

The range of human intelligence is astonishing. At the bottom of the scale are the idiots. The lowest of these never learn to talk, to dress, or to feed themselves, or to protect themselves against even the commonest dangers of life. So long as they live they must be tended like babies. For some purposes it is convenient to define an idiot as a person whose mental age will never be greater than three years. A higher grade of the feeble-minded, who are still

unable to care for themselves, are the imbeciles. These may reach a mental development as high as that of the average six-year-old child. Those whose development can be compared with that of children from six to twelve years of age are called morons.

A commonly accepted grading of levels of intelligence in terms of the IQ is the following—

IQ	*Verbal Description*	*Percentage in Each Group*
0- 25	Idiots	
25- 50	Imbeciles	3
50- 70	Morons	
70- 79	Border line	6
80- 89	Dull normal	15
90-109	Average	46
110-119	High Average	18
120-129	Superior	8
130-139	Very superior	3
140 and above	Gifted	1

The third column shows the percentage of 2,904 children from two to fourteen years of age classified in each of the groups. It probably represents fairly well the distribution of intelligence throughout our population.

It is important not to attribute either too little or too much importance to the results of an intelligence test. We ought to think of the results of any one test as only one line in a portrait. By itself it means very little. If we wish

to reach a real understanding of any individual we may be studying, we must consider it together with all the other information we can gather. Viewed in such a setting, it may be very valuable and revealing indeed. Only a well-trained psychologist, though, is competent to interpret the results of tests; and he may find it difficult to explain to anyone less well trained just what they do mean.

There is a common belief that brilliant children usually are disappointing in later life, and even as children show serious physical or other defects.

The truth of the matter is that practically all famous men were superior children. And a study of children who have scored 140 and better on intelligence tests shows that they are slightly superior to average children on nearly all other counts. They are a little taller on the average, a little stronger, a little healthier, a little better-looking, and somewhat better adjusted socially.

CHAPTER XVI

LEARNING

A THICK, juicy beefsteak, sizzling on a platter in the midst of rich, brown, crisp onions! As you read these words, does your mouth water?

Do you see anything strange in the fact that some small black marks on white paper should cause saliva to flow? Could we train you so that you would salivate whenever we ring a bell?

Pavlov trained dogs to salivate not only at the sound of a bell but also at a flash of light, a scratch on the skin, or a slight electric shock. In general it seems that almost any response of which a human being is capable can be tied up to almost any stimulus to which one is sensitive. We are obliged to use the word "almost." Many possible tie-ups no one has yet tried to make. Others have been found very difficult. Some tie-ups scientists have tried to make without success. There probably are limits to what can be done, but no one knows just what those limits are. The process by which we connect a response with a stim-

ulus that did not at first arouse it is called "conditioning."

Ivan P. Pavlov won the Nobel Prize in 1904 for his studies of digestion. About that time he began his study of conditioning the salivary secretion in dogs.

Pavlov took remarkable pains to control all the factors affecting the animals he was studying. The room in which the animal to be observed was placed was sound-proof. The experimenter watched the animal from an adjoining room through peep-holes and with the aid of mirrors. He presented the various stimuli to the animal by means of mechanical controls. Specially designed apparatus recorded mechanically the time and the number of drops of salivary secretion.

The dog was placed on a table and in a comfortable harness. A tube was attached to its cheek to collect the saliva. A small dish of meat powder pushed under its nose would start an increase in the secretion of saliva. At the same time that the meat powder was presented, or very shortly before it, some other stimulus was presented—say the sound of a buzzer. After the two stimuli had been presented together a number of times, the buzzer was sounded but *no* meat powder was supplied. In spite of the absence of this original stimulus to salivation, the increase in secretion of saliva appeared. The sound of a buzzer, that at first might only have caused the dog to prick up

its ears, now caused it to salivate.

One of the almost innumerable variations of this procedure consisted in using, instead of the buzzer, an electric shock to the foreleg. This would naturally cause the animal to pull its leg away from the apparatus that supplied the shock. As the experiment went on, the withdrawing movement gradually dropped out. The dog learned to take the shock without a quiver. In similar experiments with other painful stimuli, careful observation of the pulse and the breathing failed to show the least trace of any disturbance.

In another experiment two tuning forks of different pitches were used. When one of them was sounded, the dog was fed. If the other was sounded, it was not fed. In this way it is possible to measure a dog's ability to discriminate differences of pitch. In still another experiment on discrimination the stimuli were a paper circle and a number of paper ellipses. The dogs fairly easily learned to salivate for one but not for the other. As the experimenter used ellipses that were broader and broader, more and more like the circle, the animals found it more and more difficult to make the discrimination required. When the ellipse became *too* like the circle, some of the dogs went crazy! Compelled to attempt a task that was too difficult for them, they acted very much like human

beings in similar difficulties.

Many experiments like Pavlov's on dogs have been tried on human beings. People have been trained so that the pupils of their eyes would contract at the sound of a bell. Others have been trained so that the pupils would expand. The wink and the withdrawal of the finger from an electric shock have also been conditioned to stimuli different from the ones which originally aroused them.

Emotions seem particularly easy to condition, and the consequences of such conditioning are of the greatest importance. The most famous experiments of this kind were those in which a little boy, eleven months old, was taught to be afraid of a white rat. Each time the child touched the rat, a loud noise was made by striking two pieces of metal together behind him. A loud noise is one of the very few things that frighten babies. At the eighth trial, the baby began to cry and to show active fear the instant he saw the rat.

There are many people who do not like orange juice because they have been compelled to drink it with castor oil. Here the response of dislike so strongly aroused by the castor oil was conditioned to the orange juice, suppressing the liking that is the ordinary response to that stimulus. I am still hoping to find someone who has learned to like the castor oil because he or she took it with orange juice.

This knowledge of how emotions can be conditioned ought to enable us to understand why some people are afraid of harmless animals, of the dark, or of other things that are not in the least likely to do them any harm. We can understand, too, why some people are made really ill by foods that most persons find agreeable and wholesome. Some individuals have their digestive processes so closely tied to smoking that they cannot digest a meal without the aid of a cigarette or cigar. Some others are unable to sleep in any other bed or any other room than the one to which they are accustomed. A few people find their sleep seriously disturbed if the arrangement of the furniture in the bedroom is changed.

No one knows how far conditioning can be carried. Could children be trained to laugh when they are hurt and cry when they are pleased? That seems unlikely, and probably no one thinks the result would be worth the effort and the strain that would be necessary to achieve it. But conditioning can go very far indeed. I have read that children of deaf parents learn to cry silently! Almost any response of which a human being or animal is capable can be conditioned to almost any stimulus to which one is sensitive.

In 1911 E. L. Thorndike published his *Animal Intelligence*. Following his lead there have been almost innumer-

able studies of the ways in which animals learn. For the most part the learning has been a more complicated affair than the simple conditionings we have been discussing.

Thorndike placed a hungry cat in a cage with bars. Outside the bars, and out of reach, he placed a piece of fish. By pressing against a latch the cat could open the door of its cage and so obtain the fish. The cat, of course, did not see the situation in that light. At first it reached out through the bars and bit and scratched at them. Then it moved restlessly and apparently aimlessly around the cage. Sooner or later it accidentally pressed against the latch. The door opened. The cat ran out and seized the fish. As the experiment went on day after day, the useless movements gradually became fewer, the time until the animal pressed the latch shorter. Before very many trials, the cat would go to the latch and press it as soon as it was placed in the cage.

There have been many variations of this experiment. Another kind of learning that has been very widely studied is the learning of a maze. A rat is placed in a maze with many turns and blind alleys. At the other end of a course with many turnings is a compartment in which there is food. At first the animal wanders aimlessly around. It acts very much as you or I would do in a larger maze. Of course it does not do everything that you or I

would do, for it is not so intelligent and it has no idea of what it is all about. After some time the rat arrives at the food box and enjoys a square meal. In later trials the animal makes fewer and fewer mistakes or errors. In time it learns to go promptly to the food box by the shortest possible route.

The animals most commonly used for such experiments are white rats. That is because they are cheap to breed and feed, are easily cared for, and learn readily. Many other animals, however, have been studied; for example, the one-celled paramecium, worms, ants, turtles, cats, dogs, guinea pigs, rabbits. Raccoons are particularly intelligent animals, but their sharp teeth and their readiness to use them make them difficult to handle.

The study of animal psychology is interesting in itself and seems to be helpful for the understanding of our own mental processes. In the behavior of animals we seem to see a very simplified version of human behavior. In this simplified version we can trace fundamental factors that might be hidden and very difficult to disentangle in the more complicated behavior of men, women, and children. Of particular interest among the animals are the chimpanzees and other apes whose intelligence seems so nearly human.

Animal learning seems to be a matter of many random

movements from which the useless ones are gradually eliminated. To this process the name "trial and error" has been given. The expression is a little unfortunate, since it is the success, rather than the errors, that fixes the new modes of behavior.

How does the final success after a large number of random movements fix the correct movements and eliminate those that are useless or harmful? This again is a matter that psychologists do not understand. There have been many attempts to explain it, but none of them have been entirely satisfactory. You probably think that the animal sees the uselessness of one movement and the usefulness of another. As we watch animals, however, it seems that they do not learn in that way. They take so long to learn even simple things, the useless movements are dropped out so slowly, the correct moves are fixed so irregularly and uncertainly, that we cannot credit the animals with much if any understanding or insight. It seems that we ought to look for some simpler explanation.

A few general principles do seem to stand out and perhaps deserve to be called laws of learning. One writer in 1923 listed no fewer than twenty-three such laws. More have been formulated since.

One is the law of frequency or practice. Other things being equal, the more frequently a particular response is

connected with a particular stimulus, the stronger becomes the bond between them. Repetition of an act in response to a stimulus does tend to fixate it as the response for that stimulus.

This is very far from being the complete explanation, however, of learning. It is entirely possible to repeat an act many times and yet not really learn it. Probably many Episcopal clergymen have read the various services of their Church hundreds of times and yet would be unable to go through a service without the Prayer Book. They have not set themselves to memorize the services. There are many other illustrations of the principle that repetition alone is not enough to explain learning.

Other things being equal, the last acts before success are more likely to be remembered—or fixed—than earlier acts. The first acts, too, seem to have some advantage over others. For an illustration of this principle, read a few lines of an unfamiliar poem. See if the passages you remember best are not the beginning, the end, and some particularly striking or vivid bits in the middle. This illustrates the laws of recency and primacy.

The law of effect is an extremely important one. Human beings and animals tend to repeat the actions that bring pleasing or satisfying consequences and to avoid those that result in unpleasantness or annoyance. This law

has been particularly stressed by Thorndike. It is very difficult to understand just how pleasure or unpleasantness can reach backward and fix or eliminate the actions that led up to it. It does unquestionably seem to do so, however, and until we can work out some simpler explanation, we shall have to allow it to stand as Thorndike enunciated it.

The law of effect is extremely important for the understanding of human nature. It gives us the answer to the question we so often ask, How did he (or she) get that way? The answer is that the person in question found that way of behaving satisfying, or at least less distressing than other ways that to us might seem more natural. If we wish really to understand such a person, we must understand what emotional needs or cravings the queer way of behaving satisfies. If then we want to help, we must show some more effective and acceptable way of obtaining the satisfaction that is craved. The cure for criminality and for many forms of mental disorders can be boiled down to the simple formula—give them something better to do.

When human beings are given mechanical puzzles to solve, they behave very much like animals. They fumble with the puzzle until it suddenly is solved—they do not know how. So far their behavior seems to be of the trial

and error type shown by white rats and Thorndike's cats.

A new feature appears, however. Sooner or later one catches on. After that the puzzle is solved at once. This sudden change from fumbling and blundering and accidental success to practically perfect performance is regarded as evidence of insight.

A rather large part of human learning is practice. We have seen in our first chapter that practice improves almost any performance. Improvement means that we accomplish a larger amount of work in a given time, or take a shorter time to do a given amount of work, that we make fewer mistakes, and that we work more easily, with less effort, fret, and strain.

Improvement is seldom regular. It is rapid at first, but soon it seems to reach a limit. For some time there seems to be no improvement at all. There may even be a little falling off. It is very important that the learner should not become discouraged. If he will keep on plodding, improvement is almost certain to come in time.

Especially careful and interesting studies have been made of practice in typewriting and telegraphy. In both of these the investigators found that learners began to receive or send or type single letters. They could deal with only one letter at a time. If you have ever used a typewriter, you know how slow such work must be—even

after you have learned where the keys are. Performance at this level soon reached its limit—far below the standards set by commercial practice. In time, however, both telegraphers and typists began to deal with whole words as units. Even some phrases that were used again and again could be treated as units. This development naturally resulted in a great improvement in the work.

We shall have a little more to say about some kinds of learning in the next chapter. We may close this one with the remark that it is our ability to learn that makes possible all we call civilization or progress. It is the ability to learn that has enabled the human race even to survive in the struggle for existence with other animals and with the forces of nature. Considered simply as animals, human beings are rather puny, sickly creatures. Such instincts as they may possess are defective and utterly inadequate to preserve them from even the most common dangers. In place of powerful bodies and highly developed instincts human beings have the ability to learn. So they have been able to build shelters to protect their frail bodies. They have discovered remedies for their diseases. They have invented machines vastly more powerful than their own muscles. They devise weapons of many kinds with which to fight their enemies. Instruments such as the microscope and the telescope extend the powers of

their senses. With the aid of language they work out more effective ways of working and living together. They keep records. They engage in research to discover new and better ways of doing everything. The difference between the baby and the fully developed, highly trained man or woman of today is in part one of size and physical maturity. But it is vastly more a matter of learning.

CHAPTER XVII

REMEMBERING AND FORGETTING

A FRIEND of mine is finding it difficult to remember. When one of us refers to something that happened a few years or even a few months in the past, she will say, "Please help me to remember." Our help consists in naming persons, places, or events closely connected with the event with which we are concerned. Often her face lights up and she exclaims, "Oh, now I have it."

The point of this illustration is that memory is the ability to respond to particular stimuli by making an effective use of past experience. The response may be a rapid succession of images, mental pictures, of past events. It may be an answer to some question—as you would answer in words or writing, 21, if someone should ask you the product of 7×3. It may be a skilled movement, as when a batter swings at a rapidly approaching ball. Memory is not a matter of keeping information stored away somewhere in the mind, as cards might be placed in a file. It is a readiness to respond. And responses do not just

happen. They are always to particular stimuli.

In common everyday speech the one word, memory, is used to cover at least four processes that psychologists find it important to distinguish one from another. These are memorizing, retaining, recalling, and recognizing.

Memorizing means committing to memory or learning. Ebbinghaus was the first one to introduce measurement into the study of learning. He worked with long lists of nonsense syllables. To make up nonsense syllables you simply take two consonants and place a vowel between them, being careful to avoid real words or syllables that are too suggestive of words. Some nonsense syllables that I happen to recall after more than fifteen years are: hin, vav, dut, kax, yib, juv, lur, lan, nex, nig. Nonsense syllables can also be easily made with four letters—three consonants and a vowel. We can measure the effort required to memorize something either by the time consumed or by the number of repetitions needed.

The first thing such measurements bring out is that memorizing becomes increasingly difficult the longer the assignment to be learned. A list of ten syllables might be learned in, let us say, 120 seconds, or at the rate of twelve seconds for each syllable. You might expect that a list of twenty syllables could be learned in twice the time, or 240 seconds. But no, it actually took experienced mem-

orizers 400 seconds. That is at the rate of twenty seconds for each syllable, and it is more than three times as long as was needed for the ten syllables. With a list of thirty syllables, the time required increased to twenty-nine seconds for each syllable, 870 seconds in all—more than seven times as long as was needed for the ten syllables and more than twice as long as was needed for the twenty. Experiments show that increasing the length of an assignment not only gives more material to be learned but increases the time that must be spent on each item.

Another fact that becomes apparent at once is that disconnected, meaningless, or nonsense material is very much more difficult to remember than material that is meaningful, organized, or connected. Compare the time and effort needed to memorize the following lists. You can do so most easily by reading one list at the rate of about one item a second. As soon as you have finished the list, close your eyes and try to recite it. Count the number of times you are obliged to read the list until you can recite it perfectly once. Note it down. Do the same for the other lists.

The fact that we can measure the effort needed to memorize something makes it possible to compare one way or method of memorizing with another. Careful ex-

I	II	III
wok	pencil	shoes
pam	cloud	socks
zut	dog	trousers
bip	book	belt
seg	rib	shirt
ron	floor	cuffs
taz	cow	collar
vis	cape	tie
lub	sob	coat
mer	post	gloves
koj	fish	hat
yad	duke	cane

periments in laboratories have made it plain that pausing to recite is a very great help. The time spent in reciting is not lost. It greatly shortens the period of learning.

Another discovery is that what we call spaced repetition is usually more effective than continuous repetition. If you have an hour to spend on memorizing something, in many cases you will get better results if you will break it up into three twenty-minute periods than if you study the material for a whole solid hour. This means, too, that study day after day and week after week, has been proved by experiment and careful measurement to be more efficient than last minute or all-night cramming.

The separate periods must not be too short. Many lessons cannot be mastered at all in a very short time. Five

minutes on a chapter of history, for instance, would be simply wasted. Most people find, too, that it takes them a little time to get started on an assignment. Once they are warmed up, they can work rapidly and well for a considerable time. The proper division of time depends, too, upon the subject matter. Working problems in geometry, coming to an understanding of some events in history, translating from a foreign language, or memorizing poetry or Latin declensions are all very different undertakings. A division of time that may work satisfactorily with one may not do at all for another. Finally, individuals differ in this respect as in every other that we have studied.

If you wish to improve your methods of study, you must make some experiments on yourself. Find out what is the best division of time for *you*. The main points are: to allow enough time to get well warmed up, to work at top speed while you do work, and to stop before you become tired or confused. If you know you are going to spend only fifteen or twenty minutes at a task, you will find it easy to study hard for that short time. You probably could not keep up that pace for an hour. Three periods of intense concentration will accomplish much more than an hour of dawdling, distractions, and interruptions.

One result of many careful tests surprises most students. What is called the whole method is often more economical of time and energy than the part method. Most of us, when we have been obliged to memorize poetry, have done so a few lines at a time. We find it difficult to believe, until we have tried it, that it is often a real saving of time and effort to read the whole of an assignment every time until it is learned. For the first few times the results are discouraging; but soon the general framework of the assignment stands out. Then details begin to arrange themselves within the framework. The final result is a real saving.

Often, we must say, not always. Here again individuals differ. And here again the results depend to some extent upon the kind of material. Try it for yourself on poetry. Try to find a poem new to you of about twenty four-line stanzas. Memorize ten stanzas by the part method, until you can repeat the entire forty lines. Memorize the other forty by the whole method. To keep the count straight, count 1 every time you repeat a stanza and 10 every time you repeat the entire poem.

Finally, it is a great help toward memorizing if we can discern some underlying idea, plan, organization, or system. Why was it so easy to memorize the list of words beginning "shoes, socks"? Of course it was because the

words were a list of articles of clothing beginning at the shoes and moving upwards over a man's body. The twelve nonsense syllables were much more difficult, because there was naturally no plan or system to them. Many times persons who undertake to memorize nonsense syllables invent little systems of their own. The systems may be almost as nonsensical as the syllables but they do help.

Now suppose you have learned, say, 40 nonsense syllables to the point where you have been able to say the entire list through once without a mistake. Will you remember them all tomorrow? Of course not. How can we measure how much of the original learning you will retain after a lapse of time.

One way would be to see how many of the syllables you will be able to recall. Let us suppose that you will be able to recall 18 of them. That would be 45%, rather a good score.

That is not a very satisfactory method of measuring retention, however. There would be many syllables that you would *almost* be able to recall; but since you cannot quite do so, they are lost for the purposes of scoring as completely as those others that you have wholly forgotten. Psychologists say that the various syllables are at various levels below the threshold of recall. We need some way of measuring that will take account of this material

that is almost but not quite ready to be recalled.

We can obtain such a measure if we re-learn the material. The difference between the number of repetitions it takes us to re-learn it and the number required to learn it the first time seems a fair measure of the trace that remains in our minds or, as we say, has been retained. If it took you, say, 80 repetitions to learn the syllables, and if the next day you could learn the list in 24, it seems reasonable to conclude that you slipped back to where you were after 56 repetitions. Or we may say that the 56 repetitions have been saved. This way of measuring retention is called either the method of re-learning or the method of savings.

Still another method would be to mix the 40 syllables with 150 or 200 others. You would be asked to pick out of the long list those that you had learned the day before. This would give a higher score than either of the other methods. An interesting fact about it is that you would almost certainly "recognize" a few syllables that really were not in the original list.

So you see we can actually measure remembering and forgetting. There are still other methods than the three we have just considered. Though they all yield different measures of retention, they all agree in showing that forgetting proceeds most rapidly at first, more slowly after-

ward, and that some of the material may not be forgotten for a very long time indeed.

So far we have been discussing only material that has just barely been memorized. If we continue the memorizing process, we can learn the material so thoroughly that we may never forget it until old age or sickness causes us to lose all memories. Suppose that for five years you should never have occasion to use or refer to the multiplication tables. Would you forget that $7 \times 8 = 56$? I doubt it. It is possible that for a long time you may not have the opportunity to dance, swim, ride a bicycle, or to do one or another of the things you have learned well. It is very unlikely that you would entirely forget how to do them. Such very thorough learning we call overlearning. If you wish to remember any material for a long time it is important to overlearn it.

What else can we do to help our memories or, as psychologists say, improve retention? First of all we can, perhaps, develop a lively interest in the material to be learned. It is usually easy to remember things in which we are really deeply interested. A boy who thinks he has a poor memory because he cannot remember names and dates in history or the rules of grammar may know the names and batting averages of an astonishing number of baseball players, the dates and scores of football games, or

the records of track athletes.

Some kinds of material you will probably find much more difficult than others. That may be because you are not only uninterested in such things but actually dislike them. Emotional resistance makes learning difficult and forgetting easy. You may know just why you dislike a lesson or a subject. Or you may not be able to pin down the reason for your attitude. If you are obliged to learn it, you will do well to look for emotional resistances in your own mind and do what you can to change them into more favorable attitudes.

There is evidence that a short period of rest and relaxation after active study helps. It seems to give time for the material to soak in. It is much easier to remember material that is well organized than a miscellaneous collection of bits of information. So you should try to get the underlying idea clearly in mind rather than depend upon mere repetition. Spacing the periods of study has been found to improve retention. And so has reciting.

Recognition is a process that is very difficult to explain in any simple terms. We know that we have seen certain things before, but how we know it no one can tell. How our minds keep our past experiences in their proper time order is really very mysterious. We shall have to be content to say simply that recognizing something is knowing

that what we are seeing, hearing, or otherwise experiencing now is the same thing that we experienced earlier and, most probably, in a different setting.

In recognizing, as in the other forms of memory, we can make mistakes. You know, of course, that we frequently fail to recognize persons, things, or places that we have seen before. Most of us have been embarrassed more than once at failing to recognize people to whom we have been introduced a day or a week before. Somewhat surprising is the fact that we may "recognize" persons, things, or places we have never seen. Perhaps you have unexpectedly come upon someone who looks very like some old friend. You have hurried to greet him or her, only to find that you have been approaching an entire stranger. Many people have reported a very strong feeling that they have been in a certain place before, when it is easily proved that they were there for the first time. The explanation is believed to be that the person or the scene resembles an earlier acquaintance or an earlier scene sufficiently to set off, or arouse, the response that we call recognition.

CHAPTER XVIII

THINKING

One of America's most distinguished biologists, Dr. William E. Ritter, was sitting in his dining room early one morning. There was a fireplace in the room. In it a fire was burning. His little niece, six years old, came downstairs and into the dining room before the rest of the family. She was wearing a woolen sleeping suit and a cotton flannelette dressing gown. She moved too close to the fire. The back of her dressing gown caught fire. Dr. Ritter saw the flames over her shoulder.

He thought first, he tells us, of the way in which his own sister had been fearfully burned, then of another little girl who had been even more fearfully burned. He threw down the paper he had been reading, sprang to his feet, and seized his little niece. Four methods of dealing with the flames occurred to him. The first was to smother them in the garment itself. He tried it. He failed. The next was to wrap a blanket or rug around the child. There was no blanket or rug available. Water? The kitchen was

too far away, and rushing the child to it might only fan the flames to a worse blaze. The only other thing, it seemed, was to pull the garment off. He could not unbutton it. Finally he pulled it over her head, more roughly, he admits, than was really necessary. He threw the burning garment into the fireplace so that it might not set the house on fire.

The little girl was unhurt except for some singed hair. The woolen sleeping suit had protected her body. None of the flames had reached her face. She was more frightened by the rough treatment given her by her usually kind uncle than by the danger from which he had saved her. It was many days before the relations between the two were re-established on the old basis of trust and affection.

Dr. Ritter on this occasion certainly did some very fast thinking. The incident is an excellent illustration of what we mean by thinking. Before we begin to pick it to pieces, however, we should realize that in common, everyday speech "thinking" is used to mean at least four different things. As we found in studying memory, it is important to keep the different meanings distinct.

"Sometimes I set and think, and other times I just set." This remark is credited to a girl who was not very bright. We doubt that, even when she was "just settin'," her mind

was entirely blank. It is very difficult to keep one's mind from doing something. Just try to keep your own mind absolutely blank. You will not be able to do it very long. Something or other, sights, sounds, odors, images, ideas, almost certainly must have been passing through your mind. The word "thinking" is sometimes given to this purposeless, uncontrolled wandering of our minds. Thinking in this sense is any mental activity of any kind, anything at all that can be said to go on in our minds.

Thinking may mean in the second place a degree of belief short of certainty. "I am not sure," we often say, "but I think . . ." A third meaning appears when one says, "I am thinking of . . ." Fill in the blanks as you please. In this third case the thinker is dealing with things not actually present. The power of thought is more than magical. It can switch in an instant from the north pole to the south pole. It can leap out to distant stars and nebulae. It can annihilate distance and put us in touch with things that are very far away. It reaches out into time as well as into space. We think about what has been and is no longer. We can even think about what has not yet happened. Thus the past and the future shape the present and influence our behavior.

Dr. Ritter's account of what went on in his mind while he was trying to save his niece from burning brings out

a fourth meaning. Thinking in this last sense means solving a problem. Sometimes this has been called reflective thinking. It is with thinking in this sense that we shall be concerned in this chapter. We shall ask when do we think and how do we think.

We can answer the first question very briefly. We solve problems—or at least try to solve them—when they arise. A problem arises whenever we need to act but do not know what to do. The action needed may be of many different kinds. In Dr. Ritter's case it was rapid and energetic physical action. When a student is taking an examination, he must write the correct words or numbers in the proper place on a sheet of paper. A scientist or a philosopher may be searching for some general principle that will connect a number of separate observations. A statesman may be trying to outline a policy that will protect the safety and prosperity of his country. In all these cases, and it would be easy to think of many more, there is something to be done, but it is not clear at once just what that is.

Thinking of this kind is exceptional. It is not likely to occur very often in any ordinary day. Recall the illustration in an earlier chapter in which we compared a human being to a large business organization. The office boy in such an organization is not allowed very much discretion

and is not expected to do very much thinking. He may receive the mail, let us say, from the post man. He sorts it and delivers each item to the proper individual. Most of our ordinary activities are like that. We look over the situations that arise and refer them to well-established habits. Our habits deal with them in ways that we have found generally satisfactory.

Even an office boy, however, sometimes encounters real problems. Here, for an example, is an envelope marked *Urgent and Confidential*, but it is not clear whether it is addressed to Mr. Jones or Mr. James. He can solve this, of course, by taking the letter to one of the two men and explaining his uncertainty. The point is that his customary action is blocked. The settled habits are unable to deal with the matter. He must do something new, something different from the regular routine. In much the same way we find ourselves compelled to think whenever our habits of action are blocked and prove inadequate to deal with the matter in hand. Dr. Ritter had had no opportunity to develop habits of putting out fires in little girls' clothing. It was a situation that called urgently for action, but what should he do? Before he could do the right thing, he had to think. If he had had more experience in dressing and undressing children, he might have been able to unbutton the dressing gown and the little girl

would have been spared some rough handling.

Dr. Ritter solved his problem in very much the same general way in which Thorndike's cats got out of their cages or rats thread their way through mazes—that is, by a process of trial and error. His methods differed from those that animals employ principally in that much of the trial and error process was not an outward, physical activity but something inward. He did not run to the kitchen for water. He *thought* about doing so and decided against it. The trial and error process went on in his mind. Vivid mental pictures flashed rapidly before his mind's eye. Words doubtless formed themselves. Some of them, perhaps, were spoken. Others were only thought or imaged. Thinking is often a silent talking to oneself.

His first thought was of other little girls who had suffered similar accidents. The recollection served to impress him with the seriousness of the emergency. The flames must be put out. Here we have the second step of a typical bit of thinking. The first is the occurrence of a problem as a result of the blocking of habits. The second is the defining of the problem, narrowing it down, ascertaining, at least in some sketchy fashion, what must be done.

Now as the third step, we have a number of suggested solutions. (1) Smother the flames in the garment itself.

(2) Wrap a blanket or a rug around her. (3) Water. (4) Strip the gown off. (5) Pull it over her head.

Suggested solutions of problems scientists and philosophers call hypotheses. Each hypothesis must be checked. The first of these five hypotheses was checked by physical trial. The hypothesis as to the rug or blanket was discarded when a quick look showed nothing of the sort available. The third, to pour water on the flames, required several steps of thinking. The nearest water was in the kitchen. To get there would take time. The movement might make the flames worse. The fourth hypothesis was checked again by physical trial. He could not manage the buttons. In the case of the fifth hypothesis, trial led to success.

Our fourth step in problem solving, then, is the working out of our hypotheses and the trial of them. The elaboration may be either physical or only mental. Two of Dr. Ritter's hypotheses, we have seen, were never tried out in actual physical activity. A glance around the room showed that no rug or blanket was available. The mere thought that the nearest water was too far away was enough to dispose of the other. The third and fourth steps, we may note, may go on almost simultaneously. We do not wait until we have listed all the possible hypotheses before we begin to try them out. Ordinarily we try out

one, fail, try another, and so on.

Thinking in the sense we have been discussing is, then, a process of solving problems with the aid of words, usually silent, mental pictures or images, and ideas. The words, images, or ideas serve as signs for things or actions. The whole process of trial and error may be carried on in our minds before it is necessary for us to act. It is easy to see that this gives us an immense advantage over animals that are unable to think in any but the very crudest and simplest fashion. A man or woman, too, who has become skilled in working with signs (or symbols) as a result of long schooling, has a great advantage over men or women who can only work with real things.

In the first place the use of signs enables us to deal freely with things that we could never handle physically. As soon as you have learned a little arithmetic, you can figure the costs of papering a room, driving a car across the country, building a Boulder Dam, or financing a defense program. Engineers who have studied more advanced mathematics and can use other signs can tell how bridges must be built to carry certain loads, how machines must be constructed to render the services desired, and so on. With pencil and paper, or merely in your head, as soon as you have learned to use the signs, you can toss around thousands of tons of iron or concrete or millions

of dollars, all with the utmost of ease.

By using signs, too, we can deal with facts that are very far away. As we have already remarked, we can reach back into the past or forward into the future. Finally, since all this may go on only in our minds or on paper, we do not need to act until we have decided upon the way that seems most likely to prove successful. This obviously saves time and energy and, even more important, it keeps us free until we are ready to act. Once we act, we can never recall the act. We have done something we can never completely undo. But so long as we have only thought of a line of action, we can call it off whenever we choose and start over again.

To make any great progress in thinking we find it necessary to invent and become skillful in using general ideas and the words to denote them. Think of John, Mary, James, Mrs. Brown, and Mr. Jones. All these names denote particular people. For many purposes, though, we need words that will denote not some particular individual but any member of some large group. Such words are boy, girl, man, woman. A more general word still is human being. Sometimes we want to speak of human beings, dogs, mud turtles, lobsters, and robins, and so on as a single group. The word animal serves that need. Finally we sometimes need a word which can mean either ani-

mals or plants. For this need we have the word organism.

If you have ever gone marketing, you know how important it is to put the meat, fruit, carrots, butter, and so on into one large bag. A general term serves much the same purpose for thinking. It is like a large bag into which we can pack many particular items. It serves also as a kind of mental strap to go around a number of particulars that have some characteristic in common. The strap fastens them into a mental bundle. Once they are bound up in this fashion, we can deal with the mental bundle as a unit, as one thing.

These general ideas we call concepts. Concepts are of many degrees of generality. Boy is a more general term than William Smith. Human being is more general than boy, animal than human being; and organism is about the limit of this particular series. To make our particular facts into bundles, and these bundles into still larger bundles, we have to discover some common characteristic. This picking out and identifying and naming a common quality we call abstraction. Many particularly abstract ideas are denoted by words ending in "ness" or "ity." Think of what we mean by such words as quickness, goodness, redness, humanity, charity. Some degree of abstraction, however, is necessary for the invention of every common noun. Many different shapes of chairs are included

in the one word chair; many varieties of animals in the one word dog. Probably the reason animals cannot talk, except for a very few and very simple expressions, is that they are unable to form general ideas.

What we commonly call intelligence is largely the ability to make effective use of abstractions. What we call higher education is for the most part a training in the use of abstractions. Individuals differ greatly in their ability to think in abstract terms. Some find it necessary to stay close to real things, to wood, iron, or concrete with which they can work in physical fashion. Some can use abstractions and thought symbols to plan large practical undertakings. They are the managers. A few press on to deal with the most abstract ideas of all and to criticize the various processes of abstraction themselves. These are the mathematicians and philosophers. The question is often raised, Which kind of individual is the most valuable? The answer is that we need them all, and none has any right to despise any other.

CHAPTER XIX*

TAKING IT

HERE is the true story of a girl who was born without any arms but who attacked life courageously and successfully in spite of that terrible handicap. The secret of her splendid achievement you can gather from a remark made by her father. "I was determined from the very first," he told a friend, "that I would never allow her to pity herself."

She never did. She trained her feet to do the work of hands. She went through the city schools and on through college. With a pencil between her toes, with a little low table placed where she could use it, she did the work of her classes, worked examples in mathematics, and took notes on lectures.

To pay a part of her expenses she worked with the files in the college office. She moved freely around the campus and the city. With her feet, which she removed readily from loosely-fitting shoes, she would pay her fare on street

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cars with less difficulty than other girls sometimes experienced who had the normal equipment of hands and arms. Today she is happily married. She does all the work of the house except hanging out the clothes after a washing.

Now by way of contrast turn and look at Danny. Danny's teacher was sure he was feeble-minded. Either that or she was a failure as a teacher. It was a shock to her when the psychological clinic reported that Danny was really a little better than average in intelligence and entirely capable of doing the work of his grade with other children of his age.

"What does he do that seems so stupid?" the psychologist asked the teacher.

"Why, he just sits there all day long and doesn't learn a thing. He looks out of the window most of the time."

"Do you suppose he is dreaming?"

"Perhaps. But doesn't that show he's feeble-minded?"

"No. Only that he is unhappy. Danny is one of those unfortunate children who can't take it. He can't meet his troubles squarely. He is trying to dodge them or shut his eyes to them."

Then the psychologist told Danny's teacher some of the stories Danny had told the workers in the clinic. He had run away from home and had lived on the bank of a nearby river for a week. Just how he had got his meals

was a little vague, but it had been a thrilling experience. On another occasion he had gone hunting with his father. His gun had been a bit too big for him and its kick had broken his arm.

These stories and others were found to have not the slightest foundation in fact. When the investigator told Danny that she knew he had tried to fool the clinic, he smiled a little uneasily. "I guess I must have dreamed them then," he said.

Danny's mother had died. His father had married again and the second wife did not want Danny around. He had been sent to live with his grandmother and his life was not as happy as that of a twelve-year-old boy should be. So he had formed the habit of slipping away from an unsatisfying and even unsafe world into thrilling daydreams. The habit had grown upon him until he lived more in his dreams than in the real world. He was not stupid, but the teacher was not to blame in thinking him so. He took very little notice of anything she said. His outbreaks of naughtiness were really pathetic attempts to attract attention, to be for a time a center of attention, something of a hero.

History is full of stories of men and women to whom their own frailties or difficulties in their way were only challenges that roused their fighting spirit. Facing their

own weaknesses or the obstacles squarely, they mastered both and rose to magnificent achievement.

The story has often been told of how in his youth Theodore Roosevelt faced his physical weakness, mastered it, built up a splendid physique, and became the wonder of the world for his exuberant spirits and apparently limitless energy.

There is only one right way to face difficulties. That is to face them squarely, honestly, and with the determination to conquer them. Any other way of meeting them is like shutting our eyes when we are boxing so as not to see the blows that are coming at us.

We may not always win even if we do meet our problems squarely. On the other hand, we shall probably not wholly fail. Whether we win or lose, we can always make a good fight. We can keep our self-respect. We can deserve the respect of others. All this means that we shall keep mentally healthy.

There are other ways of meeting trouble. All of them are bad.

We may underrate the difficulty. Theodore Roosevelt might have said to himself: "It isn't anything very serious. I'm not very strong, but there's no need to do anything particular about it. My parents will take care of me." If he had done that, he would have remained a weak-

ling all his life.

We may refuse to meet the difficulty. Again, Theodore Roosevelt might have said: "Yes, I'm a weakling but there's nothing to be done about that. I suppose it is my fate." That, too, would have doomed him to life-long invalidism.

We may deny that there is any difficulty at all. That is not courage. It is simply stupidity. Sooner or later it is bound to ruin us.

We may protect ourselves against being hurt by never trying to do anything at all.

We may console ourselves for defeat or for not trying by recalling the wonderful things we used to do.

We may remind ourselves that others are even less successful than we have been.

We may try to preserve our own self-respect by picking flaws in others who have been conspicuously successful. This tendency is probably responsible for the popularity of books that de-bunk the great characters of history. The little failings of great men make us feel that they are not so very much better than ourselves after all.

We may spend time in daydreams that ought to be used for definite planning and vigorous work.

We may blame others for our failures until we finally develop a rich, ripe persecution complex.

We may develop imitations of disease that will fool even a doctor unless he suspects the trick.

Worst of all, we may just give up and collapse.

A boy who feels that he is weaker than his companions and unable to hold his own in contests with them ought to work hard developing his muscles and his skill. But he may find it much easier and immensely more pleasant to loaf in an easy chair and dream of wonderful achievements. Or he may devour books of adventure by the score.

Daydreams are not always harmful. Probably no athlete ever held himself to the strenuous discipline of training without dreaming of the victories he would some day win. Every artist must have dreamed, during the years of drudgery before he became a master, wonderful dreams of the beauty he would some day create. We must dream, if we are ever to accomplish anything outstanding. But dreams that serve as substitutes for a vigorous attack upon real difficulties are vicious.

One young man's difficulties were of a different sort. He was of much more than average intelligence; but he found it impossible to obtain a college degree or hold a job. He tried some four different colleges. In every one he made a fine start and his friends hoped that at last he had found the place where he would make good. But

before long he had quarreled with one or more of his teachers.

He has always been right. I mean, of course, that that is the way he tells the story. Always it has been the other person who has been wrong. He can prove it to you with a wealth of detail and the shrewdest reasoning, if you have the time and the patience to listen.

Some day this young man will ask himself why so many people seem to have it in for him. But he will not see that the fault, at least sometimes, is in himself. He may conclude that he has powerful, malevolent enemies. He may pick on the Masons, the Jews, the Catholics, Republicans, Democrats, bankers, Communists, or perhaps college professors. Persons like him have chosen all these and many more.

One step more will be to ask himself why such powerful enemies should select him for such persistent attention. He will probably conclude that it is because he is a great personage and they must for their own safety keep him down. So we shall find him enjoying delusions of persecution and delusions of grandeur. He is heading straight for serious psychological trouble.

He might have been saved from all this if he had been taught as a child to face his difficulties squarely and to accept the blame when he was really at fault. He would

have been saved if he had had the spirit another boy showed in very trying circumstances.

I came upon this boy just as he was coming from a fight. He was crying, not from pain but from rage.

"How did it happen?" I asked.

I have remembered his answer more than twenty years. It was so splendidly sane and fine. "I don't know. I don't want to talk about it now. I'm too angry to think straight."

We must begin early to learn the right attitude toward difficulties. Very fortunate indeed are those of us whose fathers and mothers taught us the right ways to meet trouble and were themselves fine examples. Alfred Adler insisted that by the age of five or six years children have chosen the plan of campaign they will follow all through their lives. Probably that is somewhat exaggerated, and certainly it is never too late to try to improve the attitudes we have adopted.

Children may decide that the way to find success and enjoy a feeling of power is to co-operate cordially with others. That is the only healthy and fully sane way. But they may feel obliged to fight for their rights in a world in which they have found reason to believe every man's hand is against them. They may try to control others by calling attention to their own weakness and pleading

for pity. They may turn from real conflicts that are always tiring and not always successful to the sure and easy triumphs of the imagination. Worst of all, they may seek to escape the shocks and jars and jolts of life by retiring within a shell and never trying to do anything at all. This is one of the tendencies of what may be called the "in-growing mind." And it is one of the worst.

Problem children, Alfred Adler finds, fall mostly into three classes. First are those who are painfully conscious of some inferiority and spend their energies trying either to conceal or to compensate for their weakness.

The second group is made up of children who are too little loved. These conclude—and they have good reason to do so—that the world is against them. They must fight if they wish to get anywhere. They expect cruelty, treachery, and meanness. They find it. They fight back with the same weapons.

The last group is of children who are loved too much. A child in the family should be neither a nonentity nor the focus of constant attention and comment. One is about as bad as the other. The spoiled child soon finds that others do not consider him nearly so important as do his adoring parents and relatives. If he could spend all his life within the family circle, he might get on very well; but his conflicts and his miseries, when he must go out into

the cold, indifferent world, can easily be imagined.

The best fun in life comes from working willingly with others. If there are physical difficulties, very probably they can be overcome by exercise and training. If difficulties arise from ignorance, there are schools, night schools, correspondence and extension courses, and libraries. If our difficulties are some of those that we have been discussing in this chapter, we can first of all face them squarely and then set ourselves to overcome them.

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